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WITH 116 ILLUSTRATIONS

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Preface

THIS is the second volume of the Scientific Amusements Series, of which *Electrical Amusements and Experiments* forms the first volume. In the present volume the author deals with experiments and amusements relating to Light, Heat and Sound. He includes many optical illusions and also some original Conjuring, which may be performed by the readers. It has been his endeavour to instruct as well as to amuse; it gives additional interest to see the why and wherefore of the various experiments. As in all his previous works, the author endeavours to get into personal touch with the readers.

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CHAPTER I

Experiments with Light

THE subject of light attracted the ancients, and they formed some curious ideas about it. Our old school friend Euclid, who founded a school of mathematics at Alexandria, had a very strange idea about light. If you had asked him what light is, he would have told you that it consisted of ocular beams sent out by the eyes, and that these beams acted like the feelers of insects. He would have explained further that all visible objects also sent out rays, and it was when the ocular beams touched these that things became visible.

Another idea was that light consisted of very tiny particles which were shot off from visible objects, and that when these entered

the eyes they produced the sensations of vision.

Now we know that light consists of a wave-motion in the mysterious æther, which we believe fills all space.

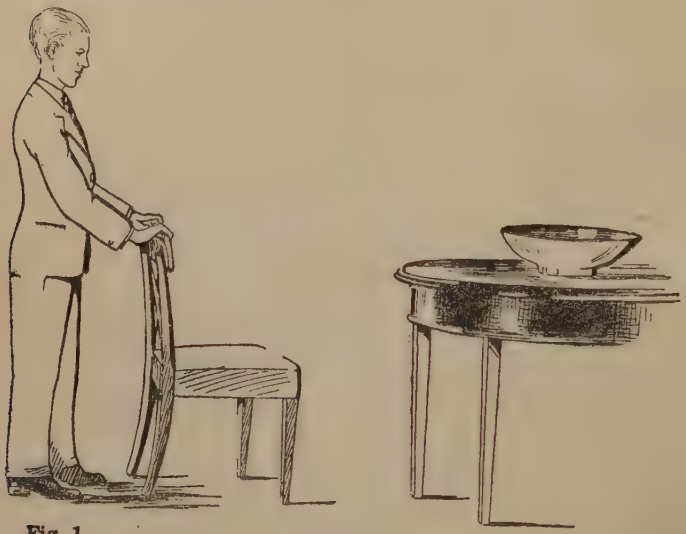


Fig. 1

A very old Experiment. Bending a Ray of Light

Go backwards until the penny in the basin disappears from sight.

It is those æther waves with which we are going to experiment.

About a thousand years ago there lived an Arabian named Alhazan, who made many experiments with light, and here is one which you may repeat very easily.

Take an empty wash-hand basin and place it on a table. Put a penny or other coin in the bottom of the basin, and then walk away from the table, going backwards and keeping your eyes on the penny. Continue going back until the penny disappears from sight, but stop as soon as the penny disappears. It is well to

Basin with Penny Hidden Fig. 2

mark your position by placing a chair in front of you, as shown in the drawing (Fig. 1). Remain in this position, and get someone to fill the basin with water, taking great care not to disturb the position of the penny.

Before the water is put into the basin, this is what you see (Fig. 2).

As soon as the water is in the basin you can see the penny as in Fig. 3.

Fig. 3 Basin filled with Water showing Penny

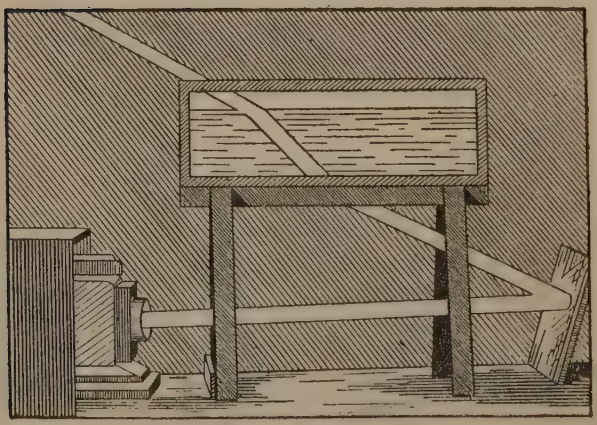


Fig. 4 Bending a Beam of Light

Why is this ? Because the æther waves of light have been bent and pass the edge of the basin. What has bent them ? They have been bent in passing from the air to the water.

This Arabian of a thousand years ago showed this very clearly by another experiment. He passed a beam of light through a glass tank containing water with a little milk added. This experiment may be repeated by anyone who possesses a large glass tank. Instead of using sunlight, we may produce a beam of light by means of a lantern, as shown in Fig. 4.

The beam of light is reflected by a mirror, placed at an angle so that the light passes through the glass bottom of the tank. A little red ink has been added to the water instead of milk, and it shows up the beam by a property known as *fluorescence.*

You will notice that the beam is bent when passing from the air into the water, and again in leaving the water and entering the air.

Another way of observing this *refraction,* as it is called, is to place a stick at an angle in water. On looking down at the stick it looks as though it were distinctly bent.

Alhazan varied his experiment with the tank by arranging the angle of the beam so

that it was reflected from the surface of the water as in the following picture (Fig. 5).

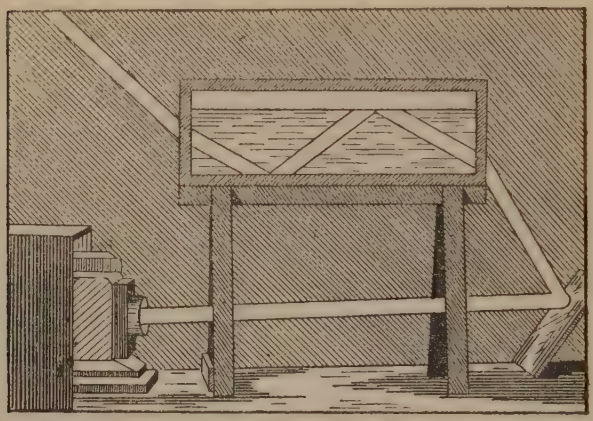


Fig. 5 Bending and Reflecting a Beam of Light

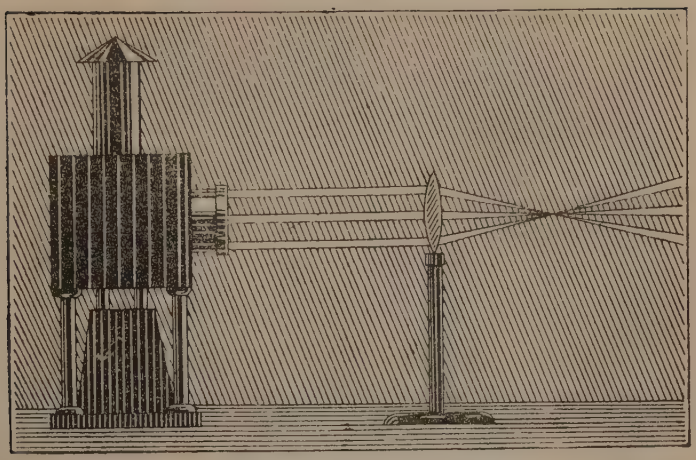
LENSES

You know the use of glass lenses in spectacles, telescopes, microscopes, and magic lanterns. If we pass a beam of light through a convex lens the result is as in Fig. 6.

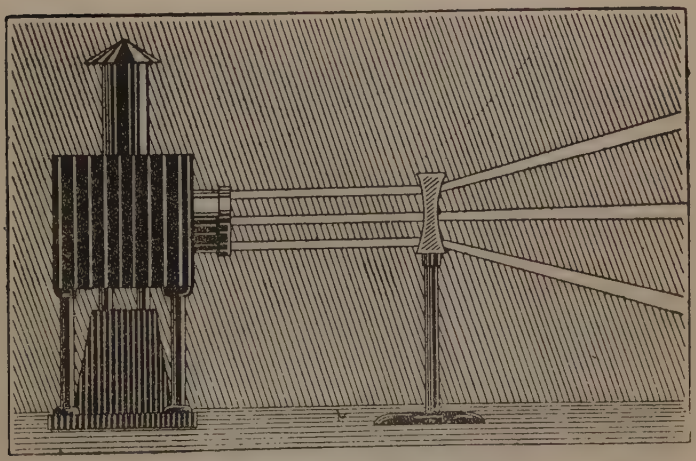
The beam is concentrated or focussed.

If we pass the same beam of light through a concave lens the light is spread out or diverged as in Fig. 7.

A long-sighted person requires a convex lens to bring the light to a focus earlier, whereas a short-sighted person requires a concave lens to



Lantern and Convex Lens **Fig. 6**



Lantern and Concave Lens **Fig. 7**

spread the light and allow the rays to focus at a more distant point. In both cases the object is to focus the rays on to the retina or sensitive part of the eye.

The retina is really an extension of the optic nerve, and there is a blind spot where the optic nerve enters the eye. You may prove this by experiment.

Close the left eye, and fix the right eye upon the cross in Fig. 8.

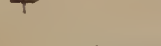


Fig. 8 Blind Spot Demonstration

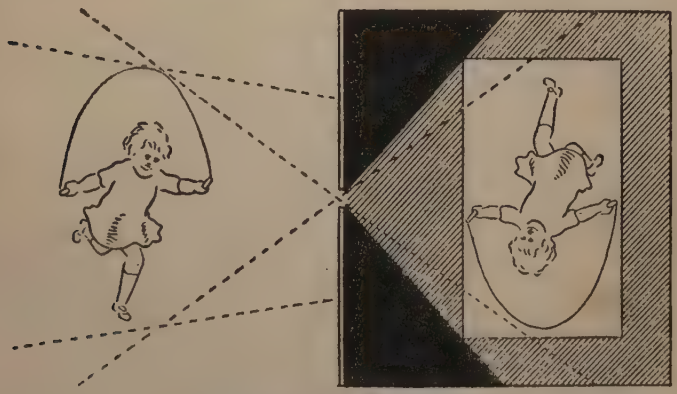
By looking at the cross and moving the book nearer and farther away you will find a position where the spot disappears.

Hold the book at arm's length, and you will be able to see both the cross and the spot. Then bring the book closer, till it is about 8 inches from the eye, gazing steadily at the cross all the time, and you will find that the spot has disappeared. Bring the book still closer to the eye, and the spot will reappear.

Another simple experiment you may make is to cause the iris of the eye to open and shut. This may be observed in a friend's eye by getting him to look at a light and then look away from it. The iris will close when the light

is shining into the eye, but the little curtain will be pulled open as soon as the light is diminished.

The experiment may be made upon oneself by looking in a mirror and placing a lighted



Inverted Image of a Girl **Fig. 9**

Showing how the eye turns what it sees upside down.

taper or candle nearer and farther away from the eye, when the iris will be seen to close and open.

One sometimes hears people asking why we do not see objects upside down when the image or picture formed within the eye is bound to be upside down.

The reason why it is upside down is very simple and is explained by the drawing above (Fig. 9).

You may make a simple experiment to demonstrate this. Place a lighted candle on the table, as shown in Fig. 10, and place a white sheet of paper as at A. Between these two, obstruct the light, allowing it only to pass

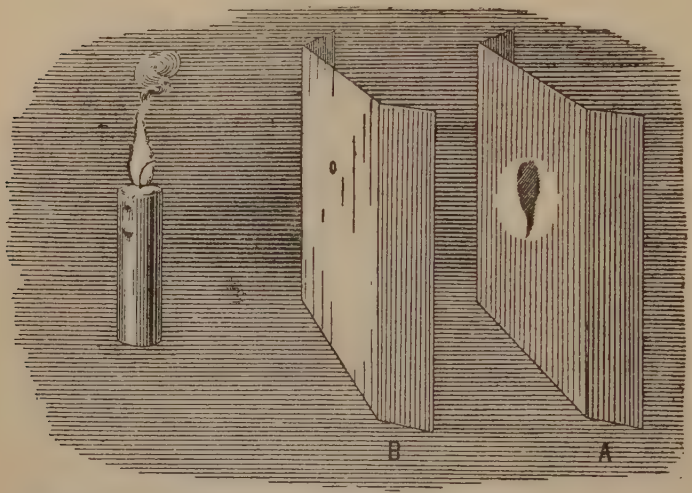


Fig. 10 Inverted Image of a Candle

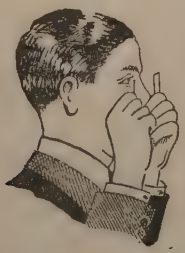
through a small hole in the cardboard B. You will find an image of the candle flame to be formed upon the sheet of paper, and it is easily seen that the flame is upside down.

Suppose you were able to form an image on the retina without its being inverted, it would give you the sensation of being upside down.

This may be done by throwing a shadow on to the retina in the following manner.

Take a piece of cardboard and pierce a pin-hole in the centre. Then hold this up between a source of light and the eye. That is to say, look through the hole either at a window or an artificial light so that the light falls on the eye, as shown in Fig. 11.

Hold a pin close to the eye, as shown in the



Casting a Shadow of a Pin on the Eye **Fig. 11**

How to prove that although our brain sees an object upright the eye sees it upside down.

drawing (Fig. 11), whereupon the light will cast a shadow on the pin, which will form an upright shadow on the retina.

On looking through the hole you will see the pin, and you will find that it appears to be upside down, as shown in Fig. 12, whereas you are holding its head upwards. When the image is inverted, as it is under normal circumstances, you read the sensation, and you see the object

right side up. Again, when we throw an upright image on the retina you read the sensation in

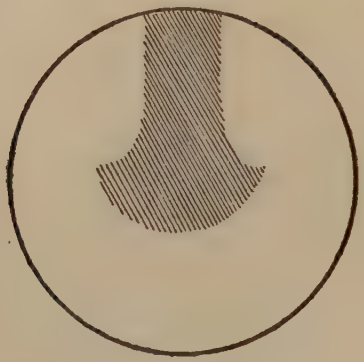


Fig. 12 The Shadow as seen

the same way, and you see the object upside down.

You will remember that you are not reading the image at all, you are merely reading a sensation in the brain.

CHAPTER II

Optical Illusions

IT is surprising how we misjudge what we have seen. For instance, if you take a long piece of cardboard and place it so that it stands upon the floor and leans against the wall of the room. Then ask each member of a party to put a mark on the cardboard showing the height of a gentleman's silk hat when laid on the floor in this position (Fig. 13).

Silk Hat and Measurement **Fig. 13**

Most people think that a silk hat is very much taller than it really is.

You will be surprised at some of the guesses as to where the hat will reach. You do not show the hat until everyone has marked off the cardboard and put their initials to their mark.

The marks will all appear very much higher up than the point to which the hat reaches, as will be seen by placing the hat in position on the floor. Indeed sometimes a mark may be twice as high as the hat.

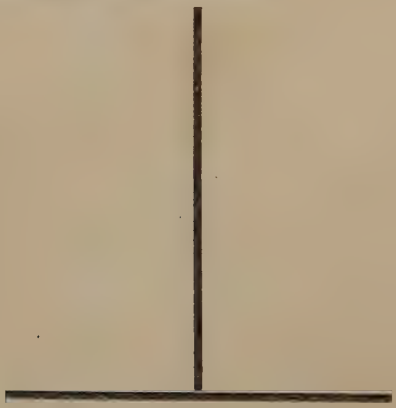
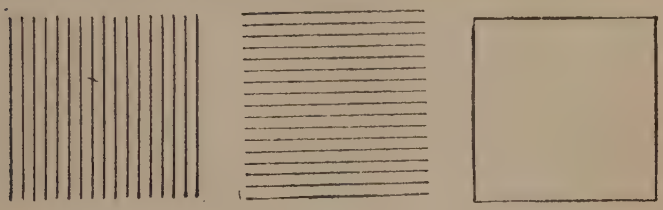


Fig. 14 Vertical and Horizontal Lines

Although these two lines look of such different lengths they measure exactly the same.

One cannot judge properly between the length of an upright line when compared with that of a horizontal line. If you were asked which of the two lines in Fig. 14 were the longer, you would no doubt say the vertical line was

longer than the horizontal one, and yet if you measure them carefully you will find that they are exactly equal in length.



Three Squares — Fig. 15

When we look at these three figures A seems to be the widest, B the tallest, and C the smallest, but all are actually the same size.

One is also deceived by the following three figures (Fig. 15).

A seems the broadest of the three figures, while B appears the highest, and C the smallest. All are equal, but summing up the vertical

Divided and Plain Lines — Fig. 16

This line is divided exactly into two equal parts. Our eyes, however, cause us to think that the left half is longer than the right.

divisions of A seems to broaden our judgment of it. While summing up the horizontal spaces adds to the apparent height. C having no divisions does not deceive us in that way.

This illusion may be shown in another form, as in Fig. 16.

The divided part of the line appears longer than the undivided part, but the two parts are equal in length.

The same idea is carried out in Fig. 17, in

Fig. 17 Dotted Line and Space

The dotted line, shown here, is of the same length as the blank space on the right, although it seems so much longer.

which the dotted space appears greater than the empty space, although there is no actual difference.

One of the most effective misjudgments is made in comparing the following two horizontal lines in Fig. 18.

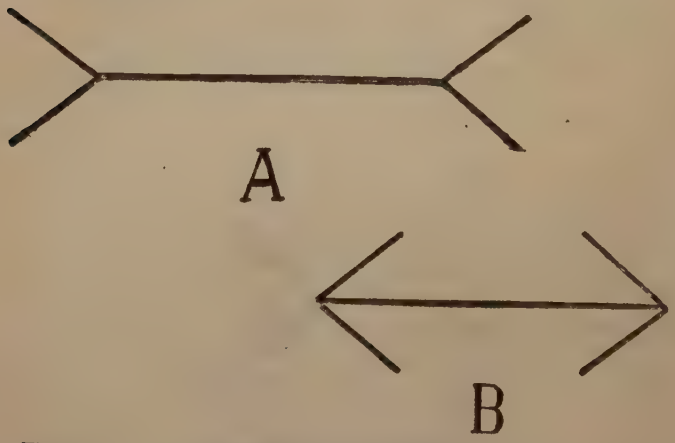
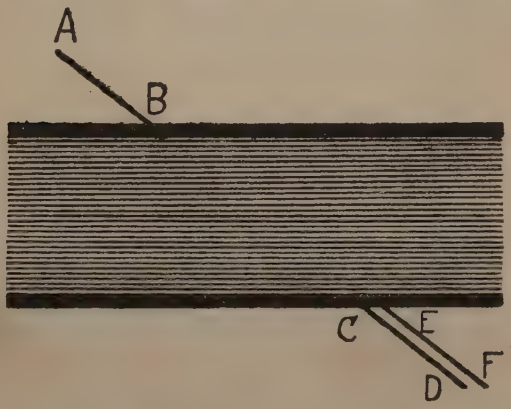


Fig. 18 Lines with Arrowheads

It is surprising to find that these two lines are equal in length. If you measure them, however, you will find that this is so.

One would have no hesitation in saying that A is considerably longer than B, but if you measure them you will find that they are equal. The lines added to the ends of A give the effect that the image is extended, while the



Which Two Lines form a Straight Line? **Fig. 19**

Is the line AB in the same straight line with CD or with EF? Although at first it seems as though AB is continued by CD, a ruler will show that it is really EF.

lines added to the ends of B do not give any extension, and it is this extension to A which causes the misjudgment.

Here is a puzzling illusion (Fig. 19). AB is in the same straight line to one or other of the lines CD and EF. No doubt you will say that AB and CD form a straight line, but if you place any straight edge on the diagram you will see that AB and EF form a straight line.

An illusion known as "Zöllner's Lines"

may be made in several different forms. One way is shown in Fig. 20, in which four upright lines, which are all parallel to one another,

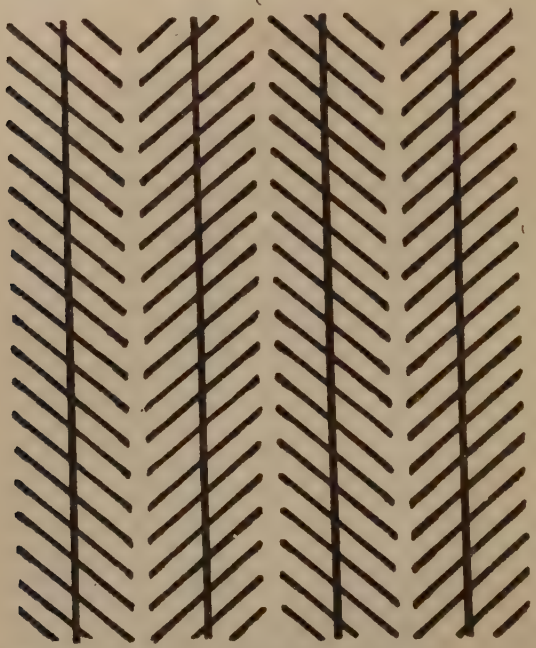


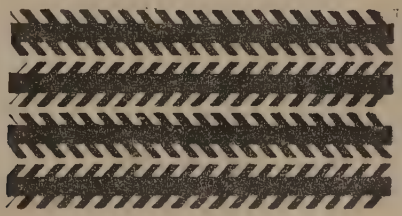
Fig. 20 Zöllner's Lines (Vertical)

These four lines are all parallel. The short cross lines make them look as though they would meet one another if extended.

appear as though they would meet if extended. The lines may be placed in a horizontal position, as in Fig. 21.

Another form is shown in Fig. 22, in which the parallel lines are enclosed in a square.

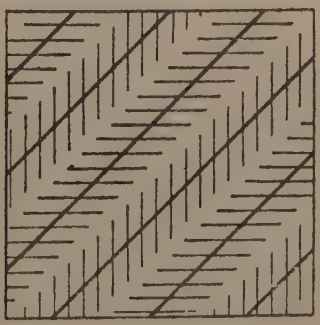
A very strange illusion is produced by Fig. 23, in which a number of crosses appear on an arc, or part of a circle.



Zöllner's Lines (Horizontal) **Fig. 21**

All these horizontal lines are exactly parallel.

If you hold the book horizontally on about a level with the chin so that your eyes look along the flat page, and if you then concentrate



Zöllner's Lines (in a Square) **Fig. 22**

Another method of showing the same curious effect.

your gaze upon the centre of one of the crosses, you will see a third line appear, standing vertically, like a pin stuck into the page. If you

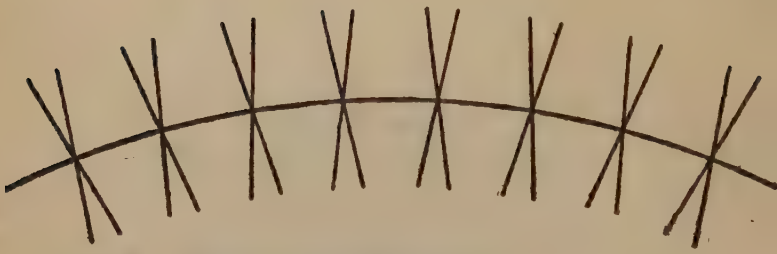


Fig. 23 Lines Standing Vertically from Paper.

If the book is held so that the eyes are looking along the flat of the page and fixed, on the point where one of the crosses cuts the circle, another line will appear, like a pin stuck in the paper.

Fig. 23A How to Hold the Book

bend your head from side to side you will see this vertical line swing first to one side and then to the other.

There are other illusions in which you can get two distinct things to appear. For instance, in Fig. 24 you may see a truncated cone, that is to say a cone with the top cut off. It is lying with its truncated face towards you so that

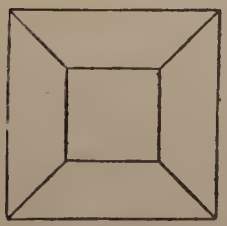
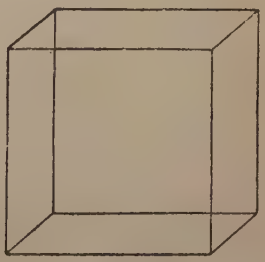


Fig. 24 A Truncated Cone



Glass Box Fig. 25

If you look at this glass box, sometimes it seems to be above you, so that you can see beneath, and sometimes it appears to be below, so that you can see the top.

you see the top. Then again you may see the figure as though you are looking into the inside of a metal pan or vessel. In the case of the truncated cone, the small square appears near to you, while in the second impression the small square is away from you. The same idea is varied in Fig. 25, in which you see a glass box. Probably you will see it at first with its base tilted as though it were slanting down-

wards towards you. Then give the book a shake and you should see it in a different position with the base slanting upwards away from you.

It is interesting to watch it change from the one position to the other.

A very telling form of this double illusion is seen in Fig. 26.

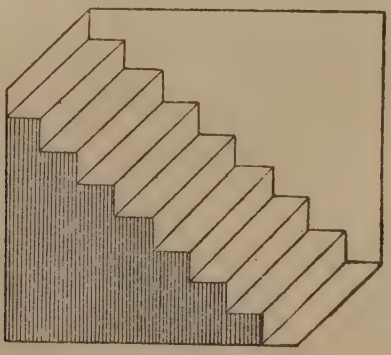


Fig. 26 Staircase Illusion

These stairs can be seen in two ways: (1) A dark flight of stairs against a white wall; (2) The underneath of a flight of steps overhanging a dark wall. (See Fig. 27.)

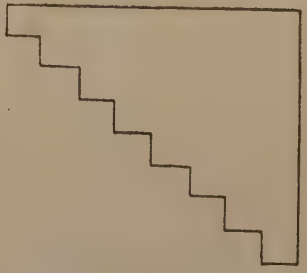
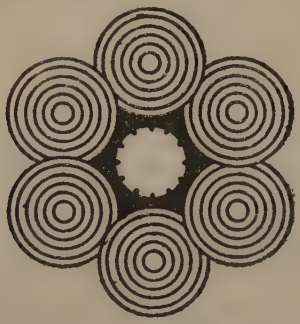


Fig. 27 Explanation of Staircase

The first impression of this will probably be that of a staircase against a wall. If you then wink your eyes or move the book suddenly you will be able to see an overhanging part like that in Fig. 27.

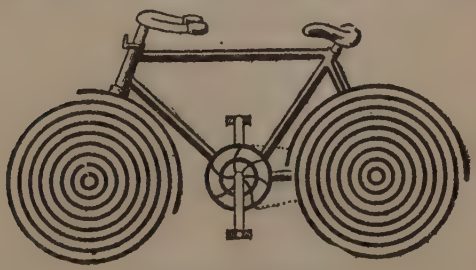


Revolving Wheel Illusion **Fig. 28**

Move the book with a circular motion and you will see the wheels go round.

In the first case, the dark portion of the figure is nearest to you, while in the second case, the white portion appears to come to the front.

In Fig. 28 we have six wheels or discs.



Bicycle Wheels **Fig. 29**

The wheels of this bicycle will revolve if the book is moved in a circle.

If you give the book a movement in a clockwise direction you will see the wheels revolve in that direction, and if you move the book to and fro in an anti-clockwise direction, the wheels will appear to revolve in that direction.

In Fig. 29 two such wheels have been put into a bicycle, and you will find that you can make the wheels revolve in either direction at will.

Another variety of the wheel illusion is seen in Fig. 30.

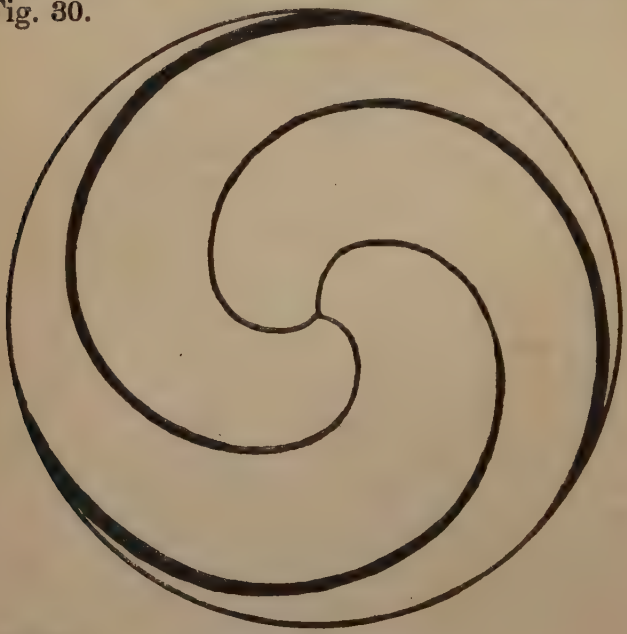
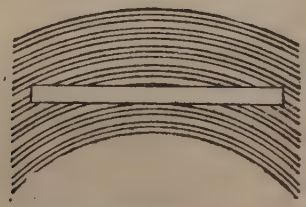


Fig. 30 Spiral Wheel Illusion

Another form of revolving wheel.

This figure requires to be given a more rapid motion in order to get the wheel to revolve. Give it a bold movement.

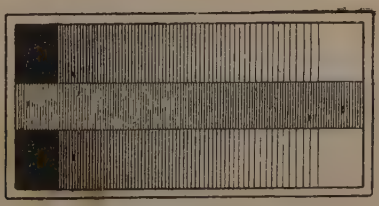
If you draw a number of arcs of circles as in Fig. 31 and place them upon a straight-edge, as shown, you will see that the straight-edge appears to be bent upwards at both ends.



A Straight Edge bent by an Arc **Fig. 31**

The ruler laid across these curves is perfectly straight.

When making Fig. 32, first draw the centre band and shade it equally from end to end. Then draw in the two outer bands, whereupon the centre band will appear to be dark at one end and lighter at the other.



Shaded Band Illusion **Fig. 32**

Although the centre band is really shaded equally all the way along, the right-hand end seems darker than the left.

In order to assure yourself that the centre band of the above figure has not been "cooked," but is really shaded alike along its entire length, you may cover up the two outside bands with pieces of opaque paper, whereupon you will be satisfied that there has been no dodging, and that the dark appearance at the one end and

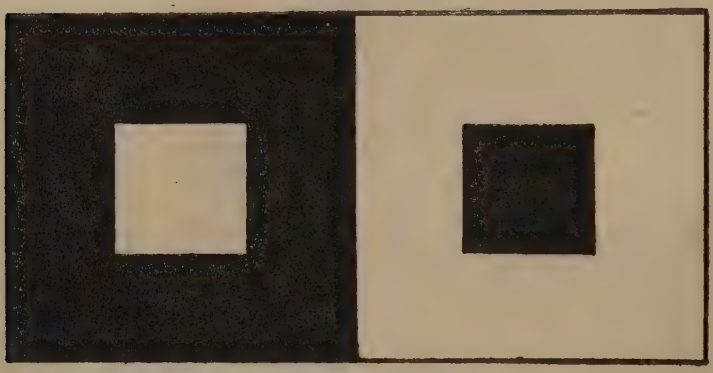
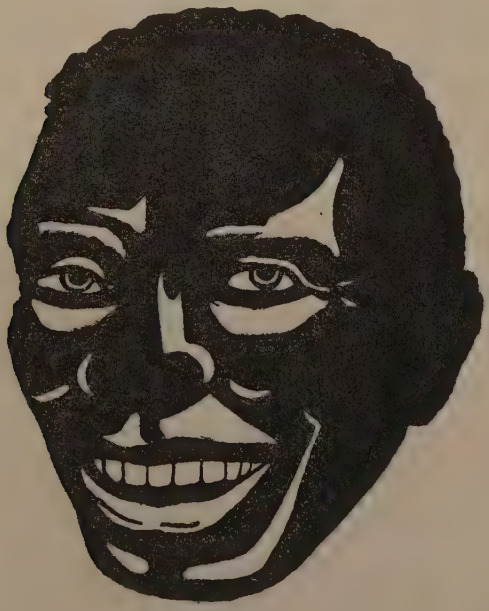


Fig. 33 Black and White Squares

the light appearance at the other end are due to an optical illusion.

Looking at Fig. 33, it looks as though the white square in the centre of the black square were larger than the black square which is in the centre of the white square. This is due to what is called *irradiation*, which means that a bright object gives a more vigorous stimulation to the retina of the eye. This is very noticeable when

one looks at an electric incandescent glow lamp when the filament is white hot. The filament looks quite a thick affair compared with the very fine wire which is scarcely visible when



Nigger's Face **Fig. 34**

Look hard at the nigger's face for one minute and then look at some dark surface. You will see the face repeated in white.

not heated. A very good way of seeing this is to view the filament through a piece of smoked glass and then without it.

If you stare at the nigger's face in Fig. 34 for one minute, and then look at a dark surface,

you will see a white face upon the dark ground. You must stare steadily, and not move the eyes.

Conversely, if you stare at the white skeleton in Fig. 35 and then look at the ceiling or at any white surface, you will see a black skeleton. While staring at the white figure you have

Fig. 35 Skeleton Illusion

Look at this white figure for one minute and you will then be able to see it in black on any white surface on which you rest your eye.

fatigued the part of the retina of the eye on which the image is falling. When you turn your eye to a white background it stimulates the retina excepting where it has been fatigued, so that the part of the white surface falling upon that part of the retina appears black.

Perspective Illusion **Fig. 36**

An old illusion is shown in Fig. 36. The three figures appear to be of different heights, but if you measure the height you will see that they are all the same. The illusion is brought about by the surrounding perspective.

Another well-known illusion is known as the cubes, and is shown in Fig. 37. There are two distinct views of the cubes, and it will help you to pick these out if you first of all take a good look at Fig. 38 and then look at Fig. 37, whereupon you will see six cubes.

If you then look at Fig. 39 and look back at

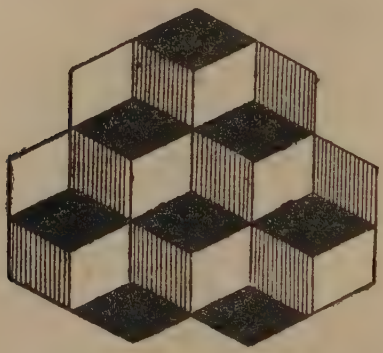


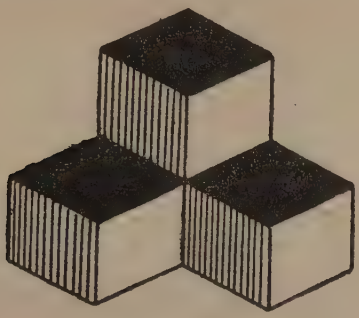
Fig. 37 Cubes (Sixes or Sevens)

Are there six or seven cubes in this drawing?

Fig. 37 you will see the other view, and you can now count seven cubes. If you have any difficulty in seeing the seven cubes, cover up the top black square for a moment. This illusion is sometimes called sixes and sevens.

In order to see the following illusion (Fig. 40) at its best, it is well to cut out the shapes No. 1 and No. 2 in cardboard You may paint the one red and the other blue. If you place the

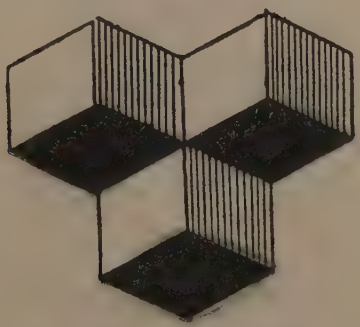
red one above the blue one, as in Fig. 40, the blue one appears to be the larger. If you place



Explanation of Cubes **Fig. 38**

By looking at these three cubes you will be able to see only six cubes if you look at Fig. 37.

the blue one above the red one, then it is the red one which seems the larger (Fig. 41). They are equal in size.



Explanation of Cubes **Fig. 39**

Look first at this figure and then at Fig. 37. You will then be able to see seven cubes.

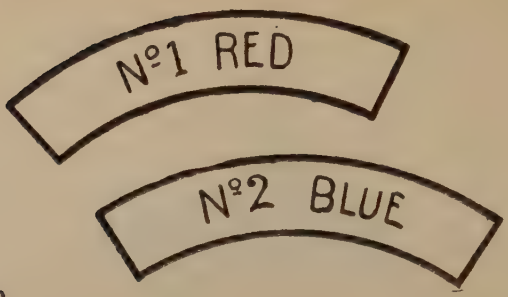


Fig. 40

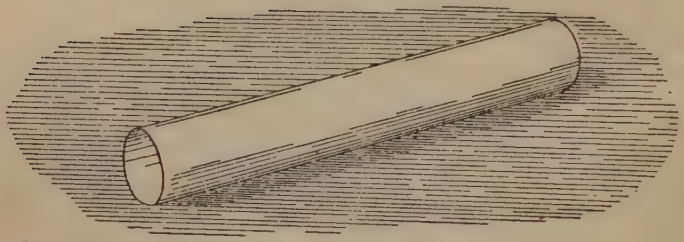


Fig. 42

Paper Tube

A small tube to be used as a telescope.

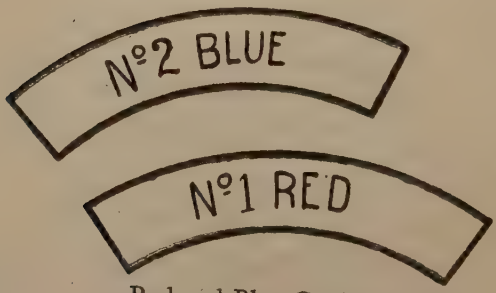
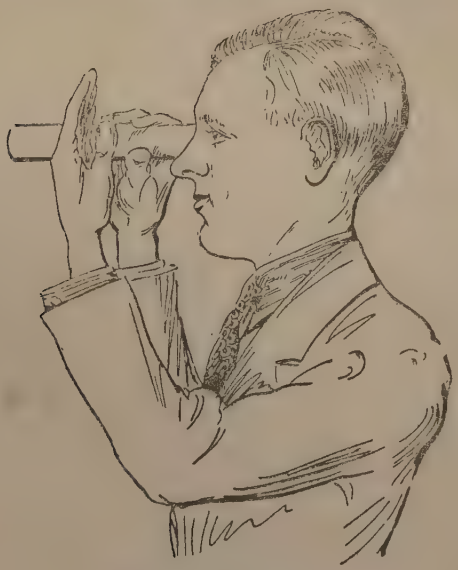


Fig. 41

Red and Blue Cards

Placed differently.

Another form of illusion is shown in Fig. 42. Roll up a sheet of paper in the form of a small tube, which is to be used like a telescope. The paper may be conveniently rolled round a ruler, which is afterwards withdrawn. The



A Boy looking through his Hand **Fig. 43**

paper may be rolled round a pencil, but the hole is better to be larger.

Having made the telescope, you place the one end to the right eye and the other end alongside of your free hand, as shown in the figure (Fig. 43). Keep both eyes open and you will find that there appears to be a hole right

through your hand through which you will see the objects in the room, or out of the window, if you are looking in that direction.

What happens is that an image of your hand is seen by your left eye, while with your right

Fig. 44

The Hole which seems to be made in your Hand

eye you see the hole in the tube and the objects visible through it. These two images are superimposed by the brain, so that the hole appears to be in the same place as the hand, hence you appear to be looking through a hole in your hand. It is a capital illusion (Fig. 44).

CHAPTER III

Moving Pictures

THE appearance of moving pictures is due to what we call the persistence of vision. That is to say, when an image is thrown upon the retina of the eye, the effect of the image continues after the object is withdrawn.

We may prove that this is so by a very simple experiment. Tie a piece of string to a piece of ordinary firewood, making sure that it cannot come loose. The best way is to cut a notch in the centre of the wood around its waist, so that the string is embedded in this notch. The reason for this carefulness is that we wish to swing the wood round and round ourselves while one end of the wood is red-hot.

If you swing this red-hot wood around in a dark room you will find that it makes a complete circle of light. Why? Because the images persist, and you see it in all the positions at the same time.

The ancients had a toy which you may copy. It had a long name, being called a *thaumatrope.*

It was dependent upon this persistence of vision.

One half of a picture was drawn on one side of a card, and the other half on the opposite side. In the illustration (Fig. 45) a bird's cage is drawn on the front of the card, and the bird appears on the back of the card.

Loops of string are fixed to the sides of the

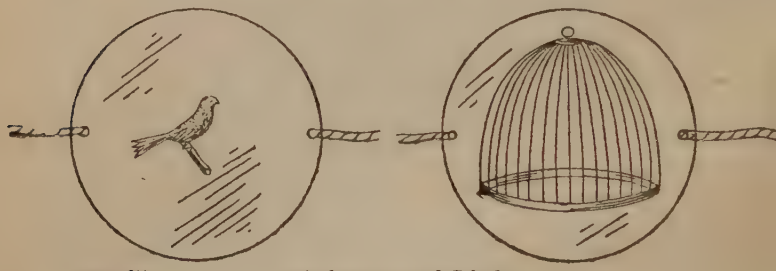


Fig. 45 Bird-cage and Bird

On one side of this cardboard disc is a cage, and on the other side is the bird. In this chapter you may learn how to make the bird go into its cage.

card so that it may be made to revolve easily. Turn the card round and round so that it twists the loops, then pull and the card will revolve. By applying the pull at the right time the to-and-fro revolution may be kept up for a long time.

While the card revolves you see a complete picture of the bird in its cage, because the two pictures persist at the same time on the eye (Fig. 46). You may draw a horse on one side

of the card, and the rider on the other; or you may draw one boy boxing at nothing, and on the other side a boy facing in the opposite direction, and in the act of boxing. When the card is in motion, you will see the two boys boxing.

You may make more elaborate pictures if you please, but you must see that you place

The Bird in the Cage **Fig. 46**

This is the image which you will see when the card begins to spin round.

the drawings in the correct position so that the two halves of the picture will fit into each other as the card rotates upon the strings.

Another old toy was called the *Phenakistoscope*, and although its name looks so learned the instrument itself was very simple.

Mount a metal rod in two bearings so that the rod will turn round freely.

Prepare two circular pieces of cardboard about 12 inches in diameter. Paint one of these black and leave the other white. If you

cannot draw well, get a friend to make a series of drawings of the style shown in Fig. 47.

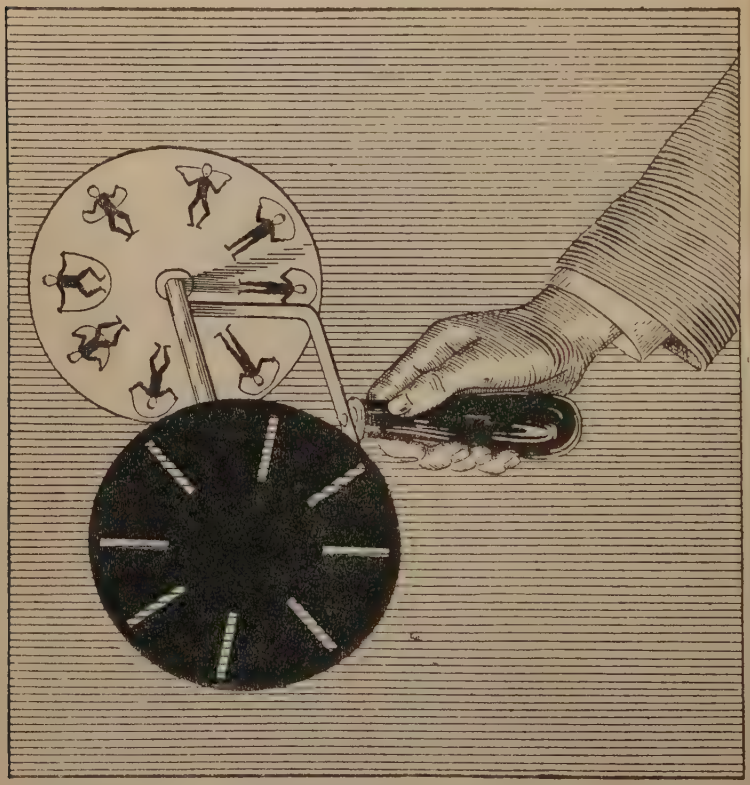


Fig. 47 A Phenakistoscope

A home-made "moving picture."

You may make the subject anything which will show motion. Each picture must show a position succeeding the previous one, so that

when you see one picture after the other the idea of motion is given. This is again due to the persistence of vision.

Having got a series of say eight pictures on the white card and in positions similar to the figures of the hours on a clock, you wish to make the black card as shown. Mark off the black card with a pair of compasses, measuring the distances between the figures of the drawing, and then marking these distances on the black card. Take care to measure from the centre of one drawing to the centre of the next one.

When the black card has been carefully marked, take a sharp-pointed knife and cut eight slots in the card as shown (Fig. 47).

In fixing these cards to the two ends of the metal rod you must take care that the slots in the black card are exactly opposite the drawings on the white card. When all is ready, look through the uppermost slot, which is in the position of twelve on a clock dial. Keep looking while you spin the cards round by turning the metal rod. This will bring each picture into view in turn. The figure in the picture will persist on the eye and will appear to move.

Another form of the same toy was called the *Zootrope*, or *Zoetrope*, or sometimes it was spoken of as the *wheel of life*.

This consisted of a metal cylinder, with slots as in Fig. 48.

If you prefer it you may make it in cardboard, in which the slots will be easily cut. For the Zoetrope the picture must be drawn on a continuous band, as shown in Fig. 49.

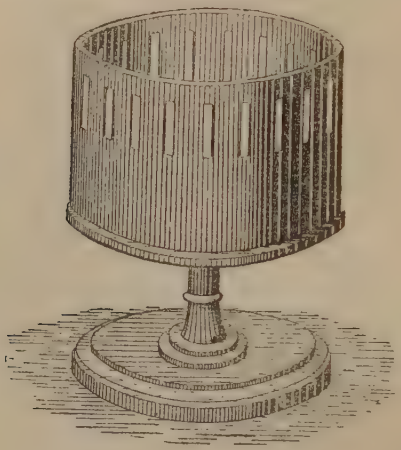


Fig. 48 Zoetrope Cylinder

The wheel of life.

It is more effective if these are brightly coloured. The band of drawings is placed within the slotted drum so that the pictures may be seen through the slots. On revolving the drum, each picture is seen in succession and the pictures seem to move.

There is another form of this instrument

with which I used to play when a boy. It had a series of mirrors at the centre. This is a distinct advantage, for when viewing the pictures in the other instruments the narrow slots cut off a great deal of the light. When viewing the pictures in a mirror the light is in no way diminished.

If you desire to make one of these toys which are called *praxinoscopes*, you will be guided as to size by the mirrors which you can buy.

Zoetrope Pictures **Fig. 49**

These should be somewhere about 2 inches in width and about 3 inches in height.

If you draw a circle of 7 inches diameter you will be able to fit ten of these mirrors in a circle to form the centre of the toy. To make these into a drum, you could cut grooves in a flat circular piece of wood, varying the size of the circle to fit the mirrors you have been able to buy. Cut a second disc or circle of wood and make exactly similar grooves in it as in Fig. 50.

One of these circular pieces forms the base of the drum and the other forms the top, so

that they hold the mirrors in position. This drum is to be revolved on an upright rod which may be made of a long wire nail, fixed in any solid piece of wood to form a base. Of course, make this as ornamental as possible if you wish your toy to have a good appearance.

Be sure to give the upright rod a good bearing to run upon, as it has to carry the whole drum with the pictures. This is obtained by boring

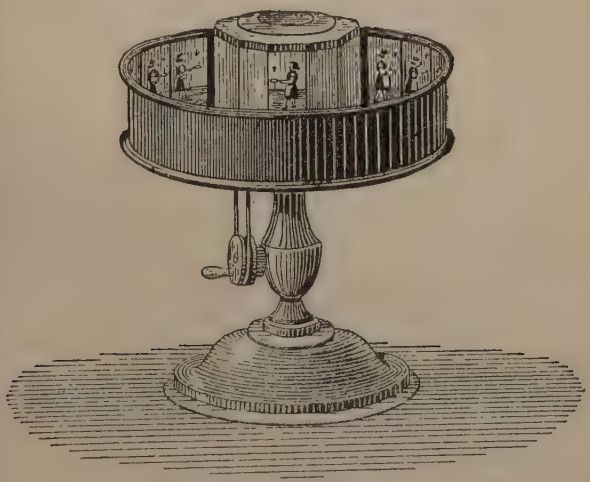
Fig. 50 Diagram for Mirror Places

a nice round hole in the centres of the two circular pieces of wood forming the drum. This may be strengthened by fitting a number of empty wooden bobbins, one on top of the other to form a pillar at the centre, the upright rod passing through the central holes of the bobbins.

When the drum is revolved, each mirror will come successively before the eye, and each

mirror will reflect the picture which is placed opposite it in the rim of the large drum. The succession of pictures will give the moving picture effect.

It was the invention of these simple moving picture machines which gave rise to the cinematograph. It came about in this way.



Revolving Mirrors **Fig. 51**

The complete wheel with the mirrors in place.

Two gentlemen in America had a dispute as to the positions of a horse's legs while in the act of trotting. To decide the matter, one of the gentlemen took a number of successive photographs of a horse when trotting. He arranged a row of twenty-two cameras a few

feet apart, and as the horse trotted past these it set off the shutter of each camera in succession. In this way twenty-two photographs of the trotting horse were obtained, and the positions of its legs could be studied at leisure.

Fig. 52 Horse Galloping

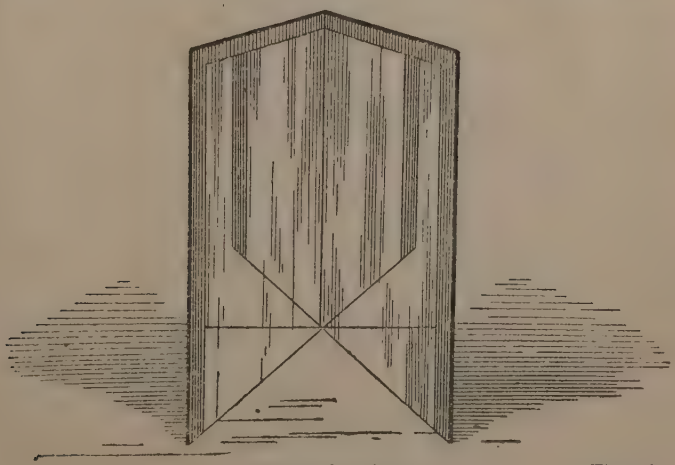
The photographs were mere silhouettes or shadow photographs, but they served their purpose. They were taken in sunlight against a white background.

This gentleman happened to send a series of these photographs to someone in Paris, who put them into a wheel-of-life toy, and showed the horse in the action of trotting. This led on to the invention of a camera in which photographs could be taken in rapid succession.

The cinematograph is dependent upon the persistence of vision just as in these toys which I have been describing.

A KALEIDOSCOPE

If you take a pair of small mirrors and join them together by a hinge of tough paper or cloth you will be able to produce good kalei-



Hinged Mirrors **Fig. 53**

doscopic effects (Fig. 53). The mirrors may be purchased for a few pence each.

Fig. 54 Simple Drawing

Draw any sort of scribble, as in Fig. 54. Then place it in the mirrors, as in Fig. 55. You will see quite a remarkable effect. This

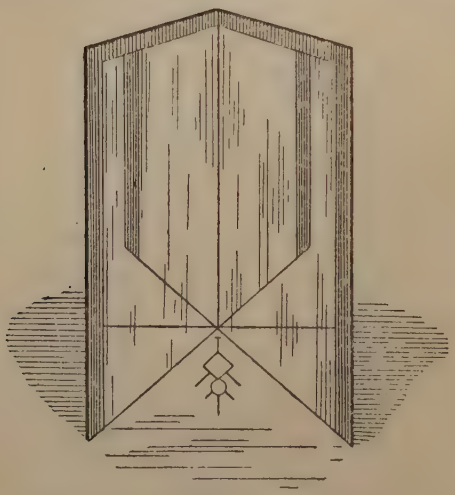
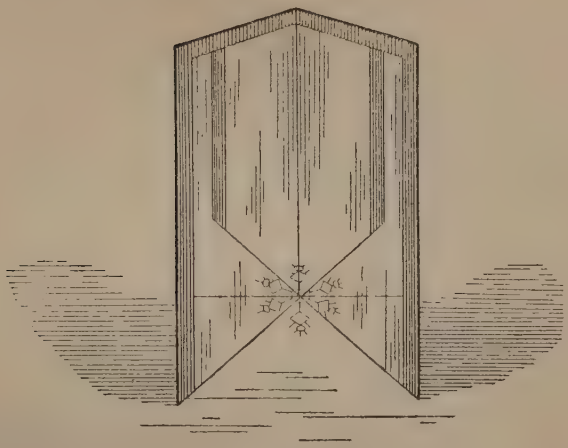
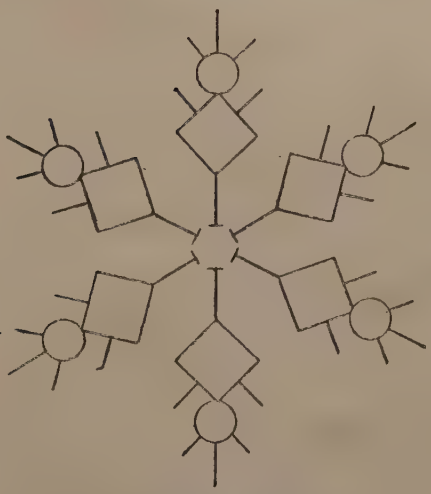


Fig. 55 Placing the Drawing in the Mirrors



How the Drawing is Reflected **Fig. 56**



The Complete Design **Fig. 57**

design (Fig. 57) will appear from the reflections of the scribble.

If you even twist a piece of thread into any simple form you may get quite a pretty effect by reflection in the mirrors.

Try placing any small object at the junction of the mirrors and see the effect.

CHAPTER IV

Experiments with Pendulums

WE are all well acquainted with the force of gravity which holds us on the surface of the planet Earth on which we live.

Some boys and girls have the idea that it was Sir Isaac Newton who discovered the facts of gravity, but that is a mistake; the facts of gravity were well known before Newton's time. What Newton discovered was that the laws applied not only to all things on the Earth, but that it was the same force which held the Moon to its course around the Earth, and that held all the planets, including the Earth, to their orbits or journeys around the Sun.

You know that things gather momentum as they fall. As the bob of a pendulum falls to its lowest point it gathers momentum to raise it to a similar point on the opposite side.

You may make a simple pendulum by fixing any metal weight to the end of a piece of thread or string.

You could not play with such a swinging pendulum for long before noticing two things.

(1) That no matter whether the pendulum makes a long or a short swing the rate per second is always the same.

(2) That the rate of swing is dependent upon the length of the pendulum.

The first fact was discovered by the Italian philosopher Galileo Galilei, who is known best by his christian name, Galileo. It was a common thing with the Italians to call their great men by their christian names.

One day in the year 1582, Galileo was sitting in the cathedral at Pisa, when he observed the swinging motion of a lamp hanging by a chain. In lighting the lamp, it had been set in motion, and Galileo observed that as the length of the swing diminished the rate of swinging remained constant. He told this by counting his pulse; there were no watches in those days.

It is, what we call, friction which brings the pendulum to rest, so when you are making a pendulum of any kind avoid all friction possible. It is easy to experiment with the rate of swing. You may alter the weight of the pendulum bob, but that does not alter its rate of swing. But if you shorten the thread on which the bob is carried you immediately hasten the rate of swing.

In the same way if you lengthen the pendulum you reduce the rate of the swing.

This does not happen in proportion to the length. If you half the length of the pendulum you do not get the pendulum to go twice as fast; you must shorten it to one-fourth of the length and then it will swing twice as fast and so on.

If you wish a pendulum to swing one beat (or single swing) per second you must make its length about 39¼ inches. The exact length for London is 3·262 feet. The pendulum swing alters to a small extent according to its position as regards the Equator and the poles of the Earth. It was a Dutch philosopher, Huyghens, who first used a pendulum in connection with a clock. This he did in the year 1658.

It was an English philosopher who invented the balance wheel for clocks and watches. A balance wheel is just a form of pendulum motion.

You may make a model of a balance wheel, as shown in Fig. 58.

To understand the principle of a balance wheel you may make a very simple experiment. Suspend a weight by a thread or string, then turn the weight round so that it twists the string. You find that it will untwist itself and revolve the weight in the opposite direc-

tion. It will overshoot the mark, continuing to twist the string in the opposite direction, and after a time it will reverse its direction again. This is the principle upon which certain clocks are made, and which are capable of going for one year. Indeed a clock has been made capable of going for a hundred years without rewinding. Better to say "rewinding," for

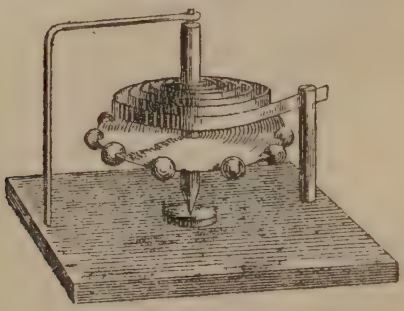


Fig. 58 A Model of a Balance Wheel

when the Irishman was told a certain clock would go for eight days without winding, he asked for how many days it would go with winding.

The principle of the twisting and untwisting pendulum is called a torsional pendulum, and I have no doubt you have seen such clocks which go for a year. They have a spring, as in the balance wheel, but instead of uncoiling at each stroke they take a year to run down.

In making a model of the balance wheel, as in Fig. 58, you may use any spiral spring from a clockwork toy and any heavy metal wheel, mounted on an axle. You stand it in a top-like position, as in the drawing, and give it any suitable bearing at top and bottom.

One end of the spiral spring must be fixed to the axle and the other to a pillar fixed in the base.

I have a pair of pendulums which act in a strange manner, and which you may make for yourself. The original was made by Mr. Joseph Goold, of Nottingham, and is known as Goold's synchronous pendulums. A drawing of the arrangement is shown in Fig. 59.

First of all procure an elastic wooden lath—a piece of lance-wood or other wood with some spring in it. A convenient size is 2 feet long by $1\frac{3}{8}$ inches broad by $\frac{3}{4}$ inch thick.

Mark off the centre of the wood, and screw in two small hooks or eyelets, one on either side of the central mark and $2\frac{1}{2}$ inches from it. The hooks will be 5 inches apart. Each of these is to carry a spiral spring. These you can procure ready made. Ask for light springs about 3 inches in length, and explain the purpose for which you wish them.

Then get two short pieces of chain, which you may buy at an instrument maker's or at a

plumber's. If each measures 9 or 10 inches it will be sufficient. Having suspended a spiral spring from each hook, then suspend one of the chains from each spring and add the weights (Fig. 59).

The ends of the wood may be supported

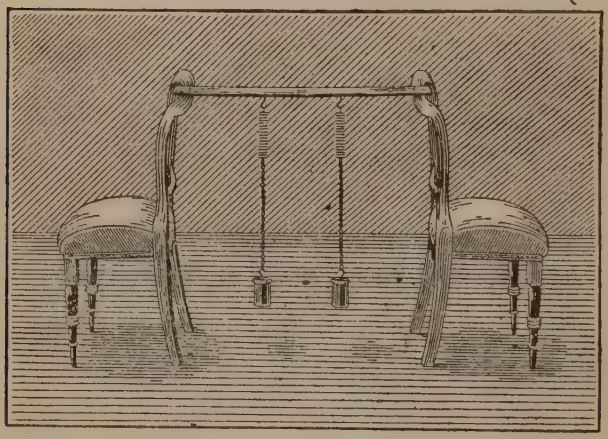


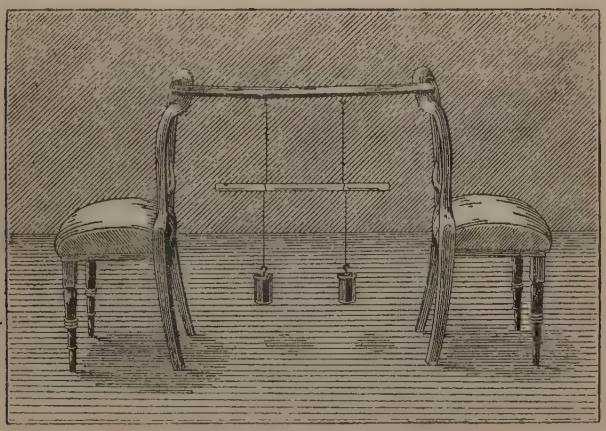
Fig. 59 Goold's Pendulums

If one of these weights is made to dance up and down on its spring it will presently stop, but the other weight will take up the dancing.

between two chairs, as shown, or in any other way which you find convenient. How do the pendulums work ?

What happens is this. If you pull down one of the weights and let it spring up it will dance up and down because of the spiral spring. Very soon the second weight will commence to

dance also, going up as the other goes down. Then a strange thing happens. No. 1 weight gradually comes to rest, and stops just as No. 2 is at its greatest movement. Then No. 1 will soon begin to dance again, while No. 2 comes to rest, and so on they go, the energy being transferred from the one to the other alter-



Weights on Strings **Fig. 60**

A simpler form of the experiment shown in Fig. 59.

nately. This will go on for a long time. My young friends used to call them "Jumping Johnnies."

The same experiment may be done in a simpler manner though not so effectively.

Fix two nails in a piece of heavy wood and have them about a foot apart. From each nail

suspend a weight by a piece of string. Then take a wooden rod and loop the strings round it as in Fig. 60. Then draw one of the weights towards you and let the pendulum swing. The second weight will soon take up the motion, while the first weight will come to rest, and so on.

You might use a window pole for supporting the weights, and a walking-stick might serve as the rod for the strings passing round.

The weights will go on transferring the energy from one to another alternately. (This arrangement saves you the trouble of getting spiral springs and chains.)

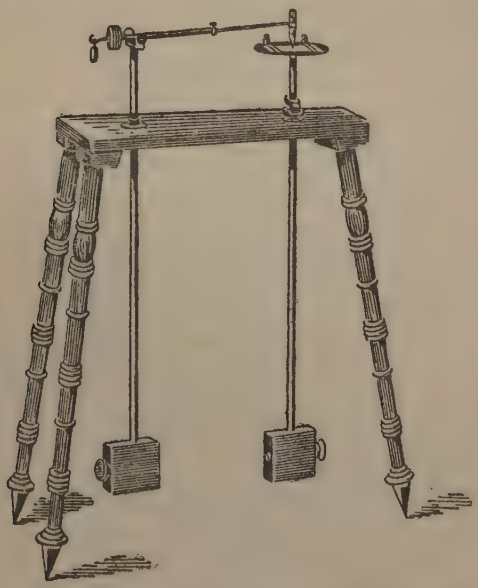
The rate at which the transference takes place depends on the position of the wooden rod. The nearer the rod is to the weights the quicker the change will be. Indeed, the rod may be placed so close to the weights that the energy is entirely transferred after each vibration, so that each weight swings once and then comes to rest.

Swinging pendulums may produce some very interesting drawings. Two pendulums are arranged as in Fig. 61.

If you can get two old clock pendulums they will serve the purpose very well. Arrange these so that they will swing at right angles to each other. No. 1 pendulum supports a flat

metal plate, on which we may place a sheet of paper or a smooth correspondence card. It is convenient to fix the paper by means of a clip.

No. 2 pendulum supports a horizontal rod,



Pendulums arranged for drawing Patterns **Fig. 61**

These two pendulums have one a pen and the other paper attached to them. When the pendulums are set swinging the pen will draw.

to the end of which is fixed a glass pen, as shown. This horizontal bar can swing up and down so that the pen may be balanced by a weight on the other end of the rod. We will see as to the making of the glass pen in a little,

but first let us see what this " harmonograph " can do.

Suppose we arrange that the pendulum carrying the pen moves from left to right, while the pendulum carrying the paper moves towards you and away from you. The pen is balanced so that it touches very lightly on the paper.

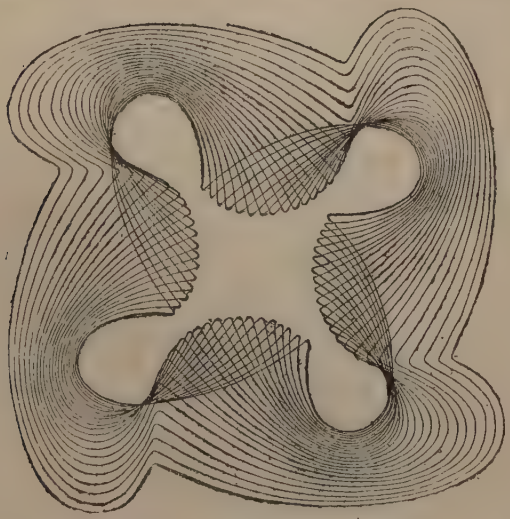
Suppose we set the pen in motion, leaving the plate with the paper at rest, the pen will draw a straight line across the paper; all we have done is to make a horizontal line. Suppose we then bring the pen to rest and set the plate with the paper swinging to and fro, it will merely make a vertical line in the centre of the paper at right angles to the first line. Now let us try the effect of swinging both tables at the same time.

Suppose we have the weights adjusted to give the same lengths of pendulums, and suppose we start the two swings of the pendulums at the same time, the pen will then draw a circle on the paper. It will be clear to you that if we now alter the length of one of the pendulums we will alter their relative rate of swing. This will give a most curious effect on the paper.

These effects would not be produced if the pen and the table always made the same length

of swing, for then the pen would continue to trace a simple curve, but the pen and table gradually diminish the extent of their swing, so that the pen takes up a new position on the paper.

A great variety of drawings is produced by



A Drawing made by Pendulums **Fig. 62**

This design was traced by two pendulums arranged so that they can swing in any direction.

not only altering the relative times of the swings by adjusting the weights, but also by starting the swing at different times relative to each other; we call this altering the phase.

A much greater variety may be obtained by

arranging the pendulums in gimbals so that they can move in any direction. Here are two figures produced by such an arrangement (Figs. 62 and 63).

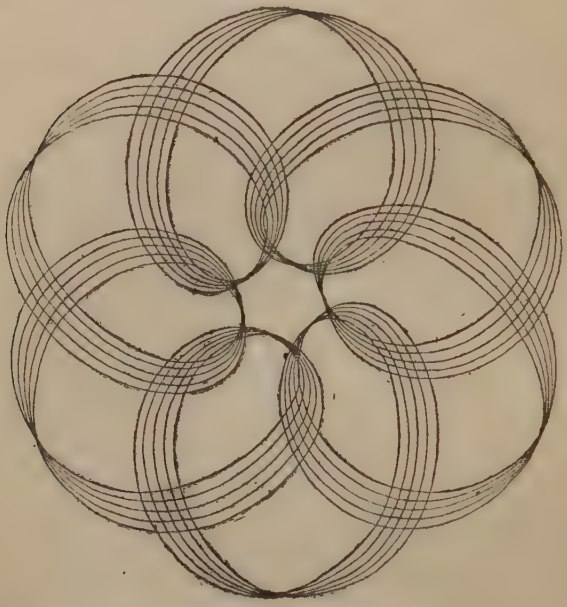


Fig. 63 A Drawing made by Pendulums

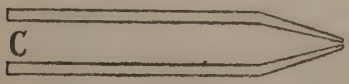
By mounting the pendulums so that they can move in any direction a large variety of designs may be made.

The making of the glass pens for the harmonograph is quite a simple process.

Procure a piece of ordinary glass tubing from any firm who supply chemical apparatus. You wish to soften a portion of the glass. This is

best done in a bunsen burner, but if you have not got one, place the tubing in the centre of any flame, and when soft draw the two ends apart, and the result will be two pointed tubes. These tubes are then sealed by holding them in the flame with the tip of the tube pointing upwards. The sealed point is then ground down carefully on a wet hone until the hole is reached. The shoulders of the point must be

Making Glass Pens Fig. 64



The Glass Pen Completed Fig. 65

Here we see the pointed end ground down until a small hole is obtained.

smooth so that they will not scratch the paper, therefore they must be ground away carefully on the hone.

Fig. 64 shows the pen as first drawn out and sealed.

Fig. 65 shows the point ground off and the shoulders nicely rounded and ready for use. You may buy the pens ready-made from the makers of harmonographs, but there is no difficulty in making them if sufficient care is taken.

Care must be taken to use a suitable and clean ink, and while the pen is not in use it should be kept in water; any good clean ink will serve the purpose, and additional variety may be given by using coloured inks.

Another important point is to use paper or cards with a good surface, such as smooth cream-wove writing paper. Rough paper is sure to trip the pen in its swinging to and fro. Avoid enamelled papers, for although they will take the ink nicely they will gradually clog the hole in the pen.

If you wish to use a very fine pen to make fine lines you may coat the surface of the paper with a strong solution of iron sulphate, allowing it to dry before using it. In this case you do not use ink, but fill the pen with strong pyrogallol, to which a little sulphate of soda has been added. These substances you will procure from any dealer in chemicals. The result of these chemicals is the production of a very black and exceedingly fine line.

You may vary your work by using a needle point and a piece of smoked paper in place of pen and paper. If you are making this alteration you need to adjust the balance weight carefully on the pen lever to suit the new conditions. For the smoked paper you should use an enamelled paper, popularly called " art

paper"; it has a glossy surface, and is used for photo illustrations in books.

You may smoke the paper by the flame of a wax taper, holding the taper horizontally underneath the paper, and moving it to and fro so as not to char the paper. The result of this experiment will be white curves on a black background, and the lines will be fine and of great delicacy, there being no running together of the lines as is often the case with ink.

These drawings may be made permanent in the following manner. Brush the *back* of the smoked paper with the following. Mix one part of hard white spirit varnish with six parts of methylated spirits. When the back of the paper is quite dry the surface may be varnished with a turpentine varnish.

If you would like to have some lantern slides of your harmonograph drawings you may make them on glass. Take some benzoline and add a little petroleum. Flood this over the surface of the glass slide, and draw the liquid off at a corner of the slide. When working with benzoline, great care must be taken that it does not come near a flame. It is dangerous even to let the vapour reach a flame, so that you must not work beneath a gas light. If you are working in electric light you are safe, but if you have to work by gas light keep away from the flame.

When the surface of the glass is dry smoke it in a candle flame, moving the glass about all the time, otherwise you may crack the glass with the heat. These take excellent drawings.

When you come to mount your lantern slide it is well to place paper strips between it and the cover glass so that the cover glass will not touch the smoked surface.

In making these glass tracings you may be troubled with loose particles of carbon being scattered over the surface, and these are apt to adhere to the benzoline surface. The best way to remove these is by electrical attraction. Take a rod of vulcanite and rub it on the sleeve of your jacket, or other woollen cloth. Use a catskin fur if you possess one. Hold the excited rod near to the glass and these loose particles will be attracted to the rod.

I have heard of a gentleman who made as many as three thousand different figures by means of a single harmonograph such as has been described.

CHAPTER V

Experiments with Sound

THE sensation of sound is generally due to waves in the air, though sound may be conducted to the inner ear through the bones of the head, as when an engineer holds a stick in his teeth and places the other end against the cylinder of an engine to hear any noises within.

Air waves or sound waves are produced by a vibrating body. This is very evident in the case of a gong or a drum. It is also quite apparent in the case of a piano, in which small hammers strike the wires causing them to vibrate to and fro.

The bowing of the strings of a violin sets them into a state of vibration, as also the plucking of the strings of a banjo, a guitar, or a harp.

A tuning fork may be caused to vibrate by giving it a simple blow, but if a large tuning fork be mounted on a wooden box, a much better state of vibration is obtained by bowing

the fork with a violin bow. These large forks are mounted on boxes open at one end, as shown in Fig. 66.

These sound boxes give a good volume of sound. A fork gives a musical note because it

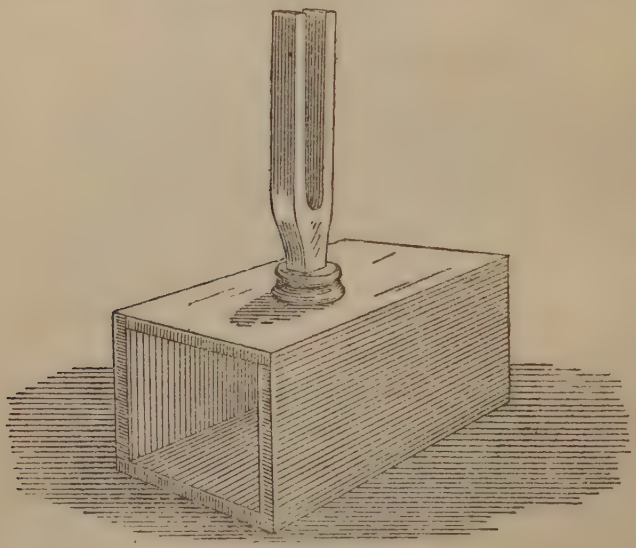


Fig. 66 Tuning Fork

produces a regular series of air waves, whereas the blow of a hammer on a board only produces a noise, which is an irregular medley of air waves.

It is worth while purchasing some tuning forks on sound boxes, as you can make the following interesting experiment with them,

and they help to illustrate a number of interesting points in connection with other things, as we shall see.

One of the most interesting experiments is to place two similar forks at a distance from one another and then set one of them vibrating. If the second fork is of the same pitch (i.e. if it makes the same number of vibrations per second), it will be set in motion by the air-waves produced by the first fork.

If we have another fork of a different pitch it will not respond to any fork which is not of the same pitch.

This is always an effective experiment. Place say a 400-per-second fork and a 500-per-second fork together, and take another 500 fork to the opposite side of the room. Set this 500 fork in vibration, and after a little catch its prongs in your hand so that it stops vibrating. You will then hear the other 500 fork singing out the same note at the other side of the room, while the 400 fork remains silent.

By placing two similar forks closer together I have been able to transfer the energy of the one to the other and then back again with only bowing the first fork. Set the two forks about 2 feet apart. Bow No. 1 and let it vibrate for a little. Then stop it, and let No. 2 fork sing out for a little with No. 1 free to

respond, which it will do if you have got up sufficient vibration to start with. The energy is transferred from No. 1 to No. 2 and back again to No. 1.

The responding fork experiment serves as a good explanation of tuning wireless instruments. A certain wave length is sent out by a transmitter into the æther of space, and only a receiver tuned to that wave length can respond. It also makes a good explanation of the reflection of light. When the æther waves of light fall upon the surface of this paper, or any other object, the æther waves set particles of electricity (electrons) vibrating, and these produce other waves in the æther which enter our eyes and produce the sensation of sight.

In order to get a bar of steel to sing out a definite note, one may give it a blow, but Mr. Joseph Goold of Nottingham invented a very much better method, which is shown in Fig. 67.

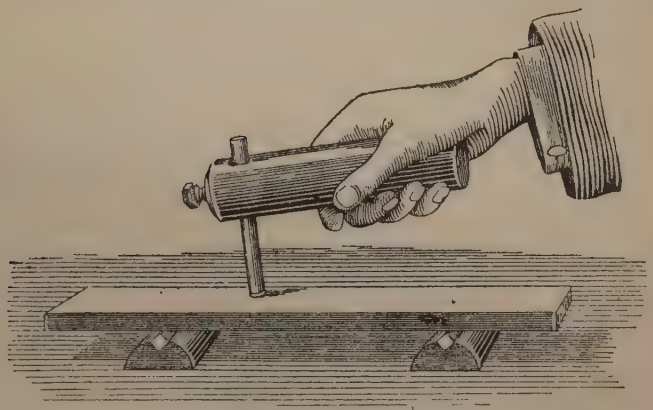
A bar of steel measuring a fraction over a foot in length and 1 inch in width with a thickness of $\frac{1}{4}$ inch will produce a note of 400 vibrations per second. That is what is called its fundamental note, but we shall see later that it can also produce much higher notes.

A piece of steel measuring a little more than

$10\frac{1}{2} \times 1 \times \frac{1}{4}$ inches will give a fundamental note of 500 vibrations per second.

Six hundred vibrations will be obtained from a bar $9\frac{5}{8} \times 1 \times \frac{1}{4}$ inches; 800 vibrations will be produced by a bar $8\frac{1}{2} \times 1 \times \frac{1}{4}$ inches.

These four bars—400, 500, 600, and 800—will give you the notes of the common chord.



Vibrating a Metal Bar **Fig. 67**

Before seeing how to make the vibrations, we may describe a very interesting experiment in the interference of sound waves.

If you have two bars very nearly the same length, say $10\frac{1}{2}$ inches and one just about $\frac{1}{16}$ of an inch shorter, or even two bars of the exact same length with a small piece drilled out of the under side of one at the centre; just sufficient to make a little difference in the mass,

so that there will be a difference of only a few vibrations per second.

Suppose one bar is vibrating at 500 per second and the other at the rate of 504 per second, something interesting will happen when you vibrate both together.

You will hear the waves interfering with one another. At certain points the crest of one wave will fill up the trough of the other wave

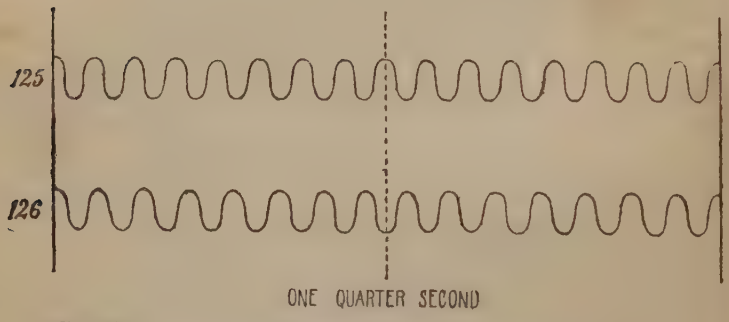


Fig. 68 Waves interfering with each other

This drawing shows us how the crest of one vibration will fill the trough of another vibration.

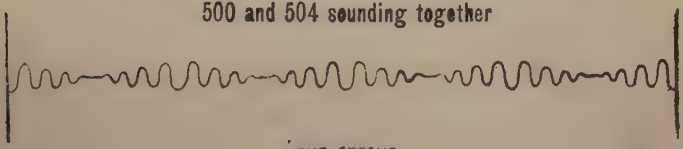
and produce a calm or silence. Let us make a mental picture of such interferences.

Five hundred vibrations per second is equal to 125 vibrations in a quarter of a second ($500 \div 4 = 125$). 504 vibrations per second is equal to 126 vibrations in a quarter of a second ($504 \div 4 = 126$).

We picture these two sets of waves starting out together thus (Fig. 68).

They start out with their crests together, and they finish up in step with each other ; but there is one wave more in the lower row, so we have to crowd another wave in, and this will bring a crest opposite a trough at the centre. This will happen once in the quarter second.

Let us picture what happens in one complete



Four Beats per Second **Fig. 69**

Two bars of steel vibrating at 500 and 504 vibrations per second will produce four distinct beats.

second which is made up of four such quarters as under (Fig. 69).

There will be four silences in each second, and when you sound the two bars you hear the silences or " beats " very distinctly.

When I received the two bars 500 and 504 I wished to test that the difference between them was really four vibrations per second, and you may test your bars just as I did.

I got an assistant to listen to the beats and make dots with a pencil on a long strip of paper, getting the pencil into time with the beats.

He kept making dots on one side of a line on the paper as in Fig. 70, and then on a given signal he crossed the line and made a straight row of dots for ten seconds, stopping the moment I cried halt, when my watch told me the ten seconds had passed since I gave the signal. We counted the dots and found that

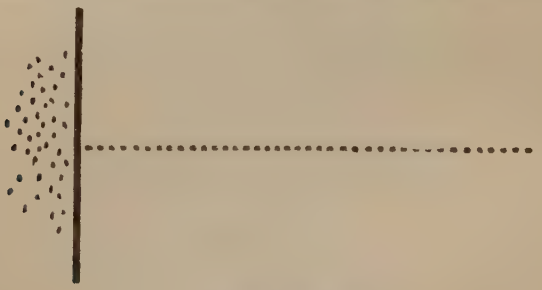
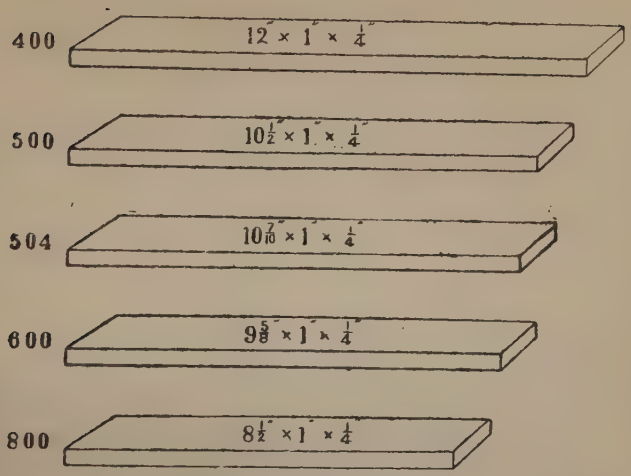


Fig. 70 Testing the Bars

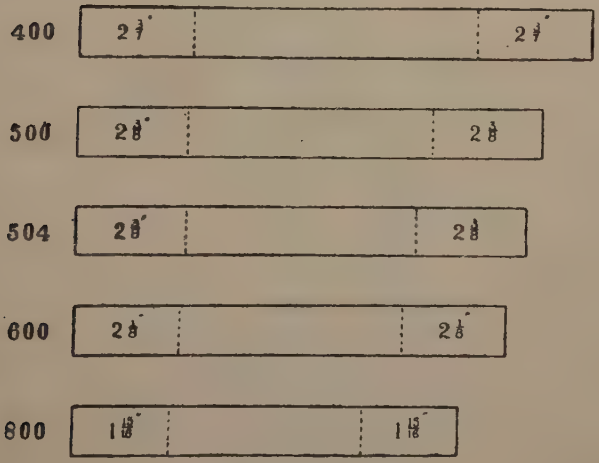
there were exactly 40 dots in the 10 seconds = 4 dots in one second, so the difference between the bars was exactly what the maker stated.

Suppose you get someone to cut the steel bars for you according to the measurements which I have given you and which I tabulate here for convenience, you will then wish to know the points at which you are to support the bars (Figs. 71 and 72).

What you wish to know now is where the nodal points are in these bars. At what points do they not vibrate? It is there you wish to



Bars of Different Sizes **Fig. 71**



Nodal Points in Bars **Fig. 72**

The exact places where you must place the supports.

support them. If you try to support them at any other points you will damp out the vibrations.

For supports you may stick on little pieces of rubber, or you may make little rubber rests upon which you can lay the bars. Either way

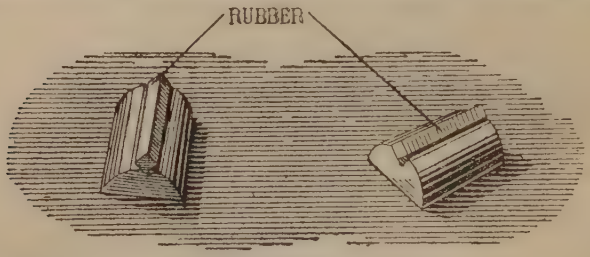


Fig. 73 Nodal Rests

Rubber rests for the steel bars.

is quite convenient, and I give you a note of the nodal points or nodes. (See also Fig. 72)

400	bar.	$2\frac{3}{4}$	inches from ends of bar.	
500	,,	$2\frac{3}{8}$	,,	,,
504	,,	$2\frac{3}{8}$	,,	,,
600	,,	$2\frac{1}{8}$	,,	,,
800	,,	$1\frac{5}{16}$	,,	,,

There is a very easy way of discovering exactly where the nodes are.

Rest the bar on two movable pieces of rubber, placing them an inch or so from the ends (Fig. 73). (You may fix pieces of square rubber in wooden or metal blocks.)

Then sprinkle a little sand on the bar and vibrate it. The sand will be thrown off the bar excepting over the nodal lines, as represented in Fig. 74.

These are the points at which you wish to fix your node rests, either fixing little feet of rubber to the bar with seccotine, or placing the bar on the movable rests.

Bar with Sand, before and after Vibration **Fig. 74**

When the bar is vibrated all the sand is thrown off, except over the nodal humour.

Now you wish to see particulars for Goold's vibrators. You may get the bars to vibrate by blows from a wooden mallet with a cloth face, but not the kind of regular vibration we wish to obtain.

The principle upon which Goold's invention is based is to use something which will vibrate at the same rate as you wish to produce in the

bar. The simplest plan will be to secure a piece of round cane about $\frac{3}{8}$ inch in diameter. Cut off about $3\frac{1}{2}$ inches of this and fix it in a heavy metal handle, such as shown in Figs. 75 and 76. This may be made of steel rod $6\frac{1}{4}$ inches long.

Any set pin you can make or get made will do so long as it will clamp the cane firmly in position. You must, of course, make a screw thread in the handle to fit the set pin.

Now the rate at which this piece of cane will vibrate will depend upon the free length of the cane from the screw or set pin to the tip of the cane. You can adjust the length for each of the rates you wish to produce, though I find it more convenient to have a separate vibrator made for each rate.

To produce 400 vibrations per second the cane must be set $3\frac{1}{4}$ inches from tip to set pin.

You may round the tip of cane, or better still fix the leather tip of a billiard cue on the end of the cane. This you can do with seccotine. You may use plain cane, leather-tipped cane, a piece of wire holding a cork, or a piece of rubber; anything will do so long as it will vibrate when you stroke the bar with it.

Having found that you can vibrate the 400 bar, you may shorten the length of cane by moving it farther through the handle, and experiment with it till it vibrates the 500 bar.

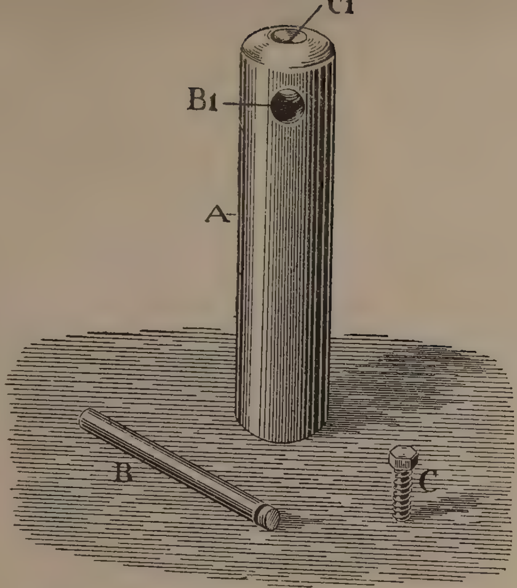
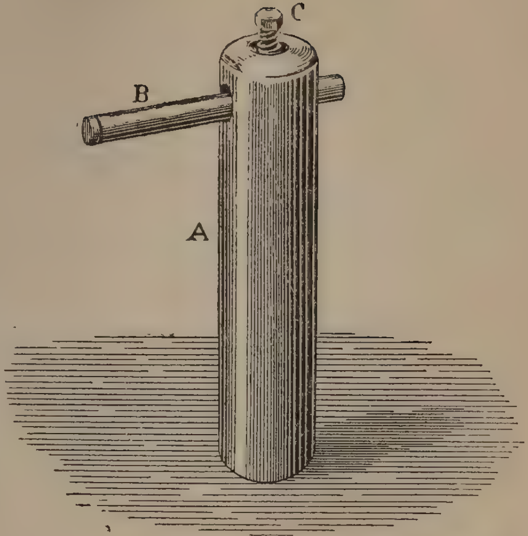


Fig. 75 Vibrator, Separated



Vibrator, Complete **Fig. 76**

In Fig. 75 are the several parts of the vibrator; in Fig. 76 these parts are put together. A is the metal handle; **B** is the cane; B1 the hole for the cane. C is the set-screw, and C1 is the threaded hole for the screw.

The same length will serve for the 504 bar. You are now ready to try the interference experiment.

To vibrate the 600 bar you must shorten the free length of the cane. No need to cut it, the spare part may stick out at the back of the handle. Then you must shorten it still farther for the 800 bar.

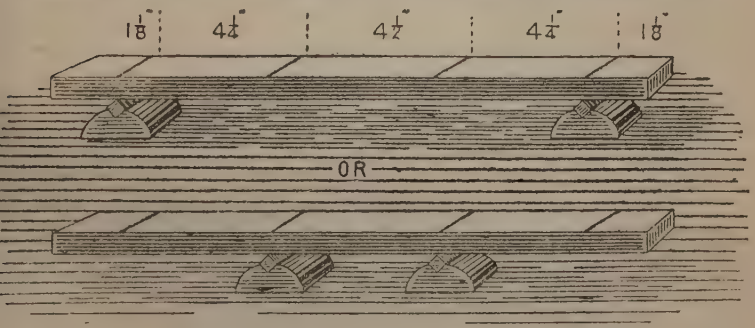
However, if you are going to work with the bars much, you will find it simpler to make a separate vibrator for each bar, using the same one for 500 and 504.

If you have the separate vibrators you will be able to sound the bars in quick succession, producing the " common chord."

If you make a vibrator with a much smaller cane about $\frac{1}{8}$ inch diameter, and about 1 inch in length, and fix it in a suitable handle which may be a good deal smaller than the first one, you will get a very high rate of vibration. You may fix this small cane into the end of a tube as you would put a pencil into a pencil-holder. The 400 bar when stroked with this vibrator will sing out a very shrill note. Sprinkle some sand over the bar and use this high-rate vibrator and you will find a number of lines appear on the bar, as in Fig. 77. The bar may rest on any of these lines as shown in the diagrams.

Try another setting of the vibrator and you will get a different set of lines. I give you some particulars of vibrators set for these bars. Here are two different sizes which serve the same purpose (Fig. 78).

One has a handle made of a piece of steel rod 6 inches long by $1\frac{1}{4}$ inches in diameter.



Bar with Four Nodal Lines of Sand **Fig. 77**

A very small cane about 1 inch in length will produce a shrill note and cause the sand to form a number of lines across the bar.

The cane measures $3\frac{1}{2}$ inches long by $\frac{3}{8}$ inch diameter.

The settings of the cane in the vibrators is given in Fig. 78, in which the measurements for two different sizes of vibrator are given. If you cannot get canes of these diameters you must experiment with whatever you get. The particulars given in Fig. 78 will give you an idea of how to set about the matter. (For Fig. 78 see p. 96.)

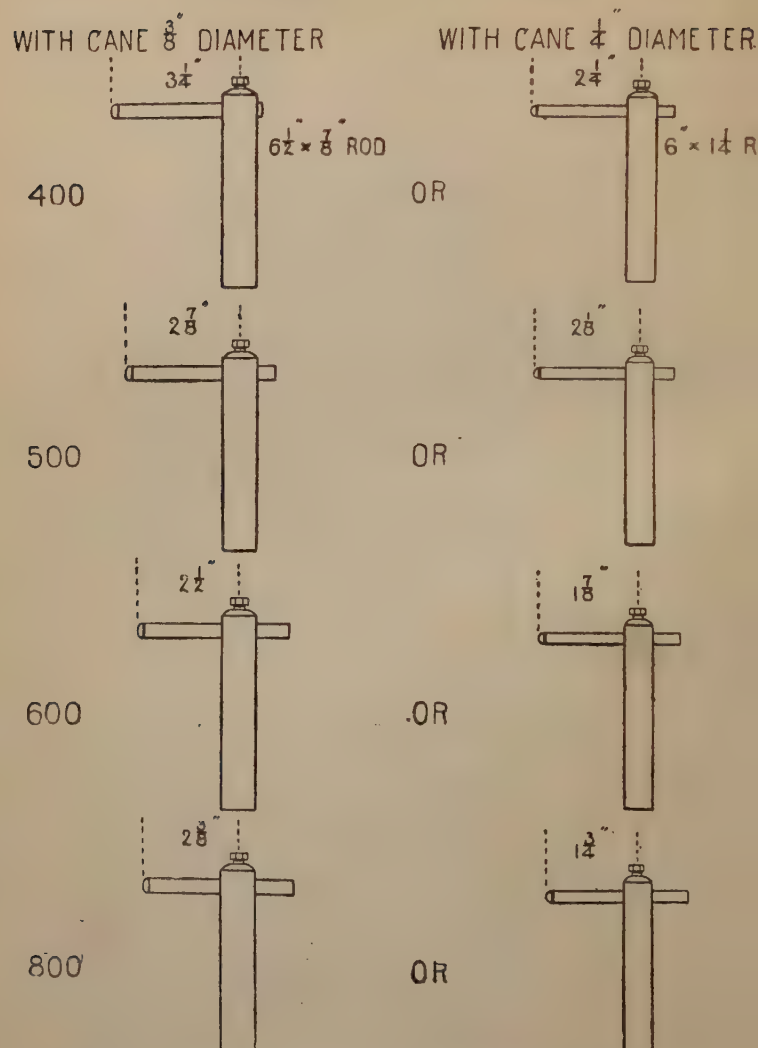


Fig. 78 Setting the Vibrators for Different Bars

These drawings will show you how to obtain the notes from different sizes of steel b

The second vibrator which serves the same purpose has a handle made from $\frac{7}{8}$-inch rod and measuring $6\frac{1}{2}$ inches in length. The cane in this case is $2\frac{1}{2}$ inches long by $\frac{1}{4}$ inch diameter. If the piece of cane is a little longer do not cut it as it may serve for some lower notes. It is not the actual length of the cane which determines the rate of vibration, but the part of it that is free to vibrate when clamped in the handle.

If you cannot get materials of these sizes just experiment with what you have, and you will soon find what length of the cane gets the bar to sing out its note. Be careful to place the bar correctly on the nodes.

If you can get a piece of cane about $\frac{3}{16}$ inch diameter and $1\frac{1}{2}$ inches long, fit this into a suitable handle, which need not be so heavy as those already mentioned, you may get the 400 bar to sing out a much higher note, and if you put sand on the bar you will find that there is now a line at the centre of the bar while the two end nodes have gone nearer to the ends of the bar. When sounding 400 they were $2\frac{3}{4}$ inches from the ends, whereas they are now only $2\frac{1}{8}$ inches.

You may get the other bars to divide up in similar fashion, and by raising the note of No. 400 higher yet you may get the bar to divide up as in Fig. 77.

If you rest the edge of a penny on any part of the bar between the nodal lines you will see how vigorously the bar is vibrating. If you then move the penny along and place it edgewise upon one of the lines it will rest there as there is no vibration at that point. In

Fig. 79 Spoon Experiment

If a spoon, tied to a piece of string, the ends of which are held to both ears, is allowed to knock against a table or chair a surprising volume of sound is heard.

making these experiments try different sizes of bars if you cannot get those of which I have given you measurements. I remember trying an old pair of bar magnets which acted splendidly.

I have given you the measurements for obtaining 400, 500, 600, and 800 vibrations per

second, which notes form the common chord. The same notes may be produced by steel bars of different weight, but if the width and depth of bar are different from what I have stated, then the lengths necessary for these notes will be different also.

An interesting experiment in sound may be made with an ordinary table spoon. Fasten it by two threads, as shown in Fig. 79. Twist the thread round one finger on each hand and close the ears with these fingers. Then bend forward and knock the spoon against a wooden table or the back of a chair and the sound heard will be something like that of an organ pipe. The sound is conducted through the bones of the head. The volume of sound is surprising.

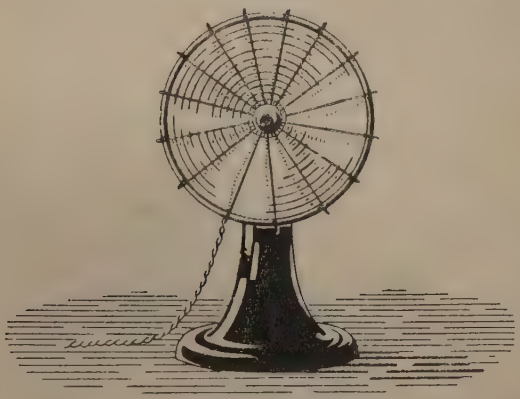
CHAPTER VI

Experiments with Heat

AT one time people thought heat to be a material thing, and for a long time it was considered as such. Now we know that heat is merely a condition of things. One object may be said to be hot while another is said to be cold, but *hot* and *cold* are merely degrees of the same thing, and both are covered by the word temperature. We may conduct heat from one object to another, but heat may take another form, as when we say that the sun radiates heat upon the Earth. On a bright, sunny day you feel these heat rays or waves warm your body. Waves in what? Certainly not air waves, for the air does not extend from the Earth to the Sun, which is more than ninety million miles away; the air is merely a great blanket around the Earth, and extends upwards from the surface only a few hundred miles. The air gets more rare as we go upwards; the great bulk of the air is within a few miles of the surface of the earth.

We may make a simple experiment with heat waves if we have two small electric radiators such as might be described as sunflower radiators. Here is what they look like (Fig. 80).

One of these radiators is to be used as a



Sunflower Radiator **Fig. 80**

source of heat, while we only wish to use the reflector of the other.

First of all remove the wire protector covering the mouth of the reflector, and then take out the element or heater which is made of fireclay on which a wire is wound. This pulls out of a socket just as a wall-plug does. You wish to place this reflector right in front of the other radiator, as shown in the diagram (Fig. 81).

We are going to get one radiator to send heat waves into the other reflector, which will focus them to a point, and the heat will be so intense that it will light a match placed at the focus.

First of all you will wish to know at what distance you are to place the reflector from the

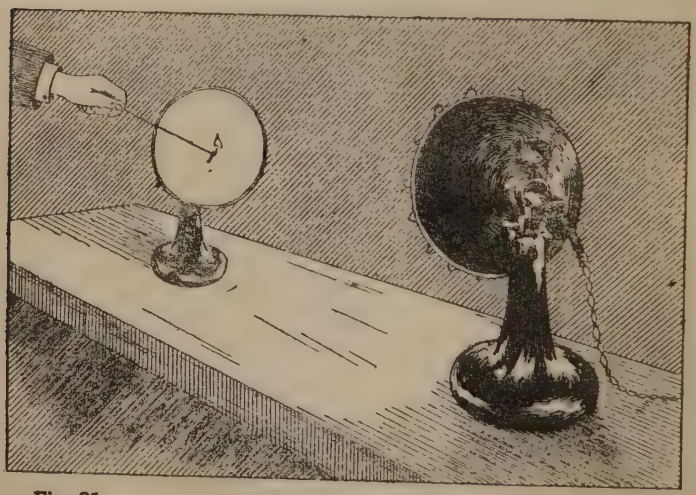


Fig. 81 Reflecting Heat Waves

The rays of heat from the radiator are made to meet on the matchhead, which is seen held in front of the reflector on the left, thus setting the match alight.

radiator. That will depend upon the size and heating power of the radiator. I have seen a successful experiment with the reflector about 6 feet away from the radiator, but with other radiators it has been necessary to place them

within 8 feet of one another. You can only find the farthest distance by experiment, and the farther apart you can have them the more telling is the experiment.

The next thing you will wish to know is how to find the focus of the reflector so that you may place the match in the correct position. You will know about where the focus is by the position of the heating element when it is fitted into the radiator. You can feel the correct position by placing a finger in the reflector shortly after switching on the other radiator. You will be able to tell where you feel most heat, and, finding that position, you will know that you have found the focus. Take notice of the position and then you will know where to place the match.

Perhaps you think of holding the match in the focus, but if you try it you will have reason to change your mind; there is too much heat. Outside of the focus it is quite comfortable, but if you get the waves all focussed on your fingers it will be very uncomfortable.

Your best plan is to attach the match to the end of a wire. Any wire, such as an odd piece of electric bell wire, will do. Twist the wire round the plain end of the match, and use the wire as a toasting fork, placing the head of the match in the focus so that it gets

the benefit of all the heat waves which are focussed together at that point.

It is better to let the radiator heat up the other reflector before making the experiment. On holding the match in position you will very soon see smoke issuing from the wood of the match, and then all at once, bang goes the head with, of course, only a very modest explosion, which will depend upon the size and composition of the head of the match. Use a wooden match and not a wax one, as it will melt and hang down out of the focus.

If you had large enough reflectors and a powerful radiator you might cook a chop or even roast beef with the heat waves. At the Royal Institution in London Professor Tyndall showed the children at a Christmas lecture some experiments with the reflection of heat waves. He had a very large reflector hanging over the lecture table and another reflector lying on the table immediately underneath the overhanging one.

(In your experiment you must see that the reflectors are exactly opposite each other and facing in the correct positions so that the waves may be sent directly into the second reflector.)

Professor Tyndall used a red-hot cannon ball as the source of heat. Electric radiators had not been invented in his time.

The cannon ball was raised by a chain and pulley arrangement so that it could be lifted into the focus of the overhanging reflector. In the other reflector, which was on the table, he placed a cigar with one end in the focus of the reflector.

If the red-hot cannon ball were placed say half-way between the reflectors, nothing happened, but when the heated ball was placed at the focus of the overhanging reflector, the heat waves were sent directly into the reflector on the table and were focussed by it on to the end of the cigar which very soon became lighted.

Professor Tyndall made many similar experiments with his pair of large reflectors.

You have been experimenting with heat waves, which are not air waves but waves in the æther of space. These heat waves are of the very same nature as light, the only difference being that heat waves do not follow so close upon one another's heels as light waves do; we say the heat waves are of greater wave length. The electric waves which we use in wireless are the very same but of much greater wave length.

Some of you may have experimented with heat waves with the aid of a lens or "burning glass." You may focus heat waves just as you do light waves by means of a lens.

On a bright summer day it is easy to set a piece of paper alight by focussing the sun's rays through a lens. You must, of course, hold the paper at the focus of the lens, and this position you will find by experiment.

You must not hold your hand long in the focus of a lens while the sun is shining on it or you will receive a very nasty burn.

I remember the case of a boy doing a very wicked thing. He had got hold of a very large lens, and taking this with him, he focussed the sun's rays on some paper objects in a shop window. The result was that these articles within the shop caught fire, and a considerable amount of damage was done before the fire brigade arrived.

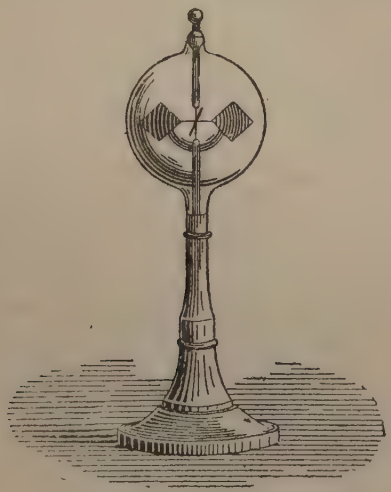
There are many innocent experiments to make with a burning glass. You may set the head of a match alight. If you are permitted to play with gunpowder, you may fire a train of gunpowder by focussing the heat waves arriving from the sun.

These heat waves from the sun may be used to drive the little vane in a radiometer. Here is a radiometer such as may be bought in most opticians' shops (Fig. 82).

I have heard people say that it is the light which drives the little vane round, but they are mistaken; it is the heat waves.

You may prove this by the following experiment.

Having placed the radiometer opposite a source of heat, such as a gas flame or a fire or electric radiator, take an alum cell and interpose it between the source of heat and the



A Radiometer Fig. 82

radiometer. The light waves are able to penetrate the cell, but the heat waves are held up. The result is that the radiometer ceases to rotate, and this proves that it is the absent heat waves which were the driving power.

If you were to use an iodine cell you would cut off the light waves and allow the heat waves to pass, so with this cell interposed, the

radiometer would be driven round in the absence of the light waves.

The conduction of heat has been referred to in the opening of this chapter. You may make

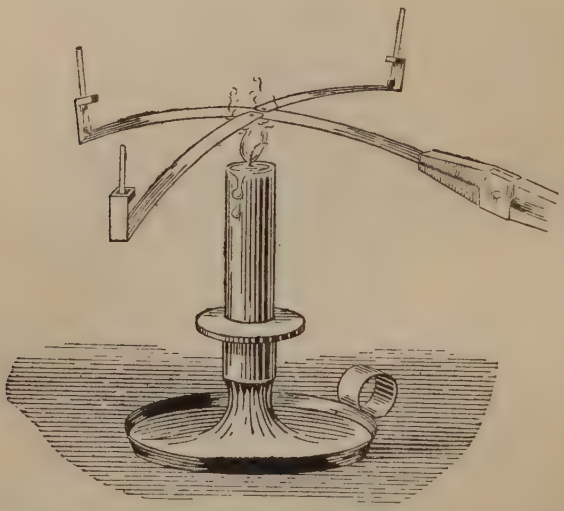


Fig. 83 Conductivity of Heat

By this experiment you may find out how quickly different metals carry heat.

a very simple experiment in the conductivity of metals.

Obtain three strips of different metals, say iron, copper, and brass. Fix them together as in Fig. 83.

Bend the ends of the strips as shown so that they may conveniently support a match. Place the matches so that the sulphur heads

rest upon the strips holding them. Heat the strips at the point where they are joined together. Use a bunsen burner or a spirit lamp. All strips should receive the same amount of heat, and when the heat reaches the outer ends of the strip the match heads will explode.

Try the experiment and you will find that the match resting on the copper will ignite first, then that on the brass, and last of all the one

A Pulse Glass **Fig. 84**

on the iron. This shows that copper is the best of the three for conducting heat. Brass comes in second best, while iron makes a poor third.

A very old scientific toy was known as the pulse glass, and this may be purchased still from opticians. This was invented by Benjamin Franklin. I have no doubt you know that while he was a distinguished American statesman he was also a scientist of high standing.

One form of the pulse glass is shown in Fig. 84, and consists of a glass tube with a glass bulb at each end. The tube is bent at

right angles near the ends, and the bulbs are partly filled with coloured water, and then the air has been expelled by boiling the water before sealing the tube.

If you let all the water run into one of the bulbs and then hold that bulb in the hand, placing the tube as shown in the diagram, the heat of the hand will drive the water along to the other bulb. The water appears to boil in the bulb to which it has been transferred.

If you hold the tube at an angle of 40 degrees the water will pulsate from one bulb to the other. This is due to the interior of the one tube becoming quickly dry, so that evaporation in it ceases. The water from the higher bulb flows back into the lower one, only to be driven out again by the heat of the hand, which causes expansion and evaporation. This takes place very easily in the vacuum within the tube.

Another experiment with the pulse glass is to place it on a table in a horizontal position, with one of the bulbs about 8 inches from a lamp flame. The other bulb requires to be shaded from the lamp, so that it receives no heat. When in this position the pulsations will take place at very regular intervals.

Another form of pulse glass is shown in Fig. 85.

This straight glass shows the evaporation of

the water in the vacuum even better than in the bent form. If you hold the bulb in the hand, the heat of the hand drives the water through the narrow neck joining the bulb to the stem. The water bubbles up and then

Another Form of Pulse Glass **Fig. 85**

condenses in the cool tube. Sometimes a small glass doll or imp is placed in the water.

You know how easy it is to set paper alight, yet it is possible to boil water in a paper bag, holding the paper in a flame (Fig. 86).

Have you ever watched the behaviour of a

candle when lighted? If it has been used before, you will find that on re-lighting it, say the following night, the flame will be bright for a very little time and then it will almost go out, but after a little it gradually brightens up again.

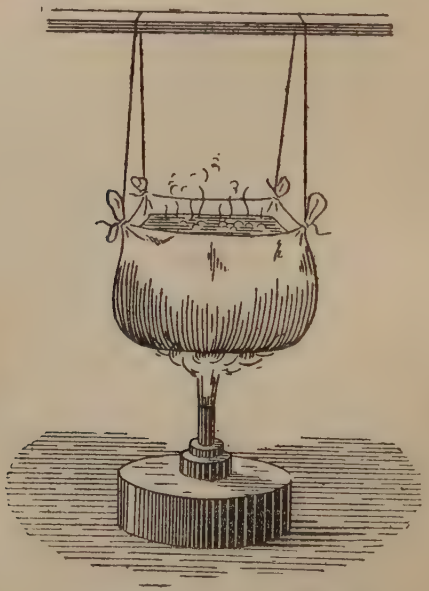


Fig. 86 Boiling Water in a Paper Bag

If you have never observed this curious fact it is worth while making the experiment.

The reason for the candle behaving in this way is that when you put a light to it there is a small amount of grease in the wick. This gives you the first flame, which quickly dies

out as the store of grease contained in the wick is used up. Then the flame dies down until the heat melts some more wax from the body of the candle.

I wonder if you have ever thought why we do not use snuffers for candles nowadays. I have no doubt you have all seen the old-

Candle and Wick **Fig. 87**

You will notice that the flame of a modern candle always bends. This causes it to get in touch with the oxygen and burn away.

fashioned scissor-like apparatus with which our great grandfathers used to snuff the candles.

The reason for this was that the wick did not burn away in the old candles, for the wick never got in touch with the oxygen of the air, as the wick remained in the centre of the flame.

Therefore the wick had to be cut away as the candle burnt down.

Take a look at a modern candle and you will see that the wick bends over so that it sticks out beyond the flame where it can get in touch with the air (Fig. 87). I think you know that the carbon of the wick joins hands with the oxygen of the air, and that this chemical action is what we call *combustion.*

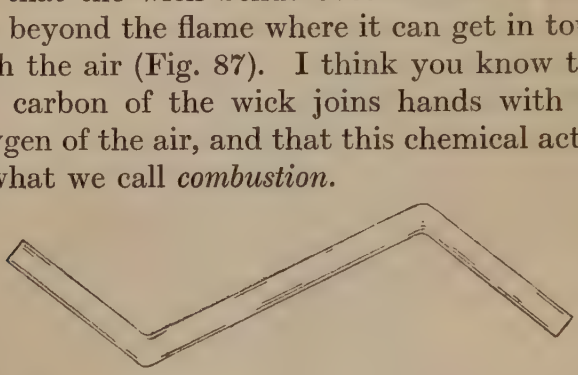


Fig. 88 A Bent Tube

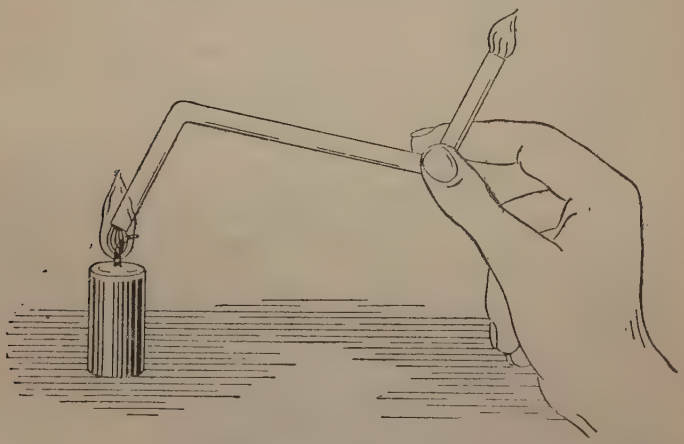
In order to draw the unburnt gas from a candle flame, you should bend a glass tube in this way.

You may make an interesting experiment with a candle flame. Take a short piece of glass tubing, which you may buy for a few pence from any dealer in chemicals. Bend it into the shape shown in Fig. 88. This is very easily done by heating the part which you wish to bend.

Hold the glass tube in a spirit lamp, or better still in a bunsen burner if you possess one. Any flame will serve the purpose. You will find that the glass tube becomes quite pliable

where it is in the flame. Then take it out of the flame and bend the tube as desired, taking care not to draw out the tube when doing so.

Having bent the tube, place one end in the candle flame, taking care that the end of the tube is in the central part of the flame. You



Gas from a Candle **Fig. 89**

When a candle burns, all the gas is not used in the flame. You may prove this by allowing the centre part of the flame to escape up the tube, where it may be set alight.

will find that this part of the flame consists of unburnt gas which passes through your glass tube and can be ignited as it escapes from the other end (Fig. 89).

If you place the end of the tube in the outer part of the flame as in Fig. 90 you will find a dirty smoke emitted from the other end of the

tube. If you hold a lighted match to this end it will be extinguished.

You may make an interesting experiment with two glass tumblers and a candle. Place the tumblers with the mouth of one resting on

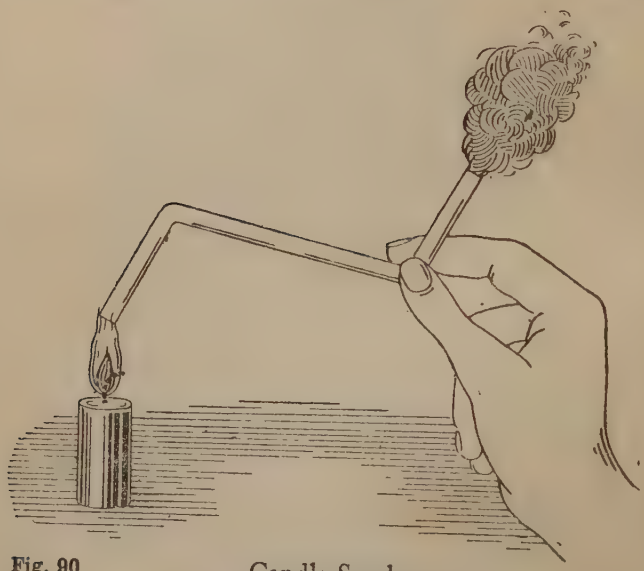


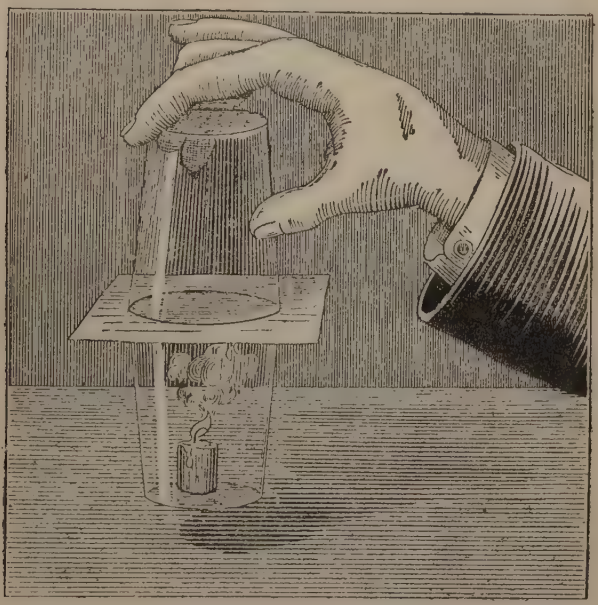
Fig. 90 Candle Smoke

The upper part of the flame will not give us a light at the end of the tube, but you will see a dirty smoke escaping.

the mouth of the other, as shown in Fig. 91. Then place a short piece of candle in the lower tumbler and cut a piece of thick paper to go between the tumblers, as shown in the diagram. Soak this paper in water, and after

lighting the candle, place the tumblers as described.

The candle will soon be extinguished for lack of air, but not till it has heated the air in the



Experiment with Two Tumblers **Fig. 91**

These tumblers are clinging together because a partial vacuum has been made by the candle heating the air and driving some of it out.

tumblers. The air becomes expanded, and some of it is driven out of the tumblers, leaving a partial vacuum. There being now more air pressure outside than inside the tumblers, they

are pressed together, and if your experiment is completely successful you should be able to lift both tumblers by lifting the upper one (Fig. 91). The paper may be scorched by the candle, but this will not interfere with your experiment unless the paper becomes broken.

It is possible to extinguish a night-light by placing a piece of copper wire in the flame. The metal conducts the heat away from the night-light, so that the reduced heat fails to melt sufficient wax to keep the night-light burning.

CHAPTER VII

How to Demonstrate Colour-blindness

THE distinguished chemist, John Dalton, was the first to write upon this subject, which was known at first as Daltonism. You will understand the subject better when we have made some experiments. What Dalton found was that he could not see the colour red.

He wished to give his mother a birthday present, and seeing in a shop window a pair of silk stockings marked latest fashion, he went in and bought them. He was very much surprised when his mother said they were very fine stuff, but that she daren't show herself at the Quakers' meetings with them as they were such a bright red.

John consulted with his brother Jonathan as to their mother's eyesight, and it so happened that Jonathan was colour-blind also, so that he agreed with John. However, the mother took the stockings to some neighbours and came back with their report, which was

that the stockings were very fine stuff "but uncommon scarlety."

John and his brother saw the red stockings as though they were a very dark drab colour, but stranger than that when Dalton looked at a pink object he saw it as a blue colour. Indeed, he was in the habit of describing pink as sky-blue. The reason for this will be clear to you when we have made our demonstration.

Some years ago I read a paper on colour-vision to one of our scientific societies, and I was asked to give a demonstration if possible. I thought it would be of interest to show colours as the colour-blind man sees them.

The commonest form of colour-blindness is that the person cannot see the colour red, so I tried to get in touch with someone who was totally blind to red.

A number of people were good enough to volunteer to take part in some experiments, but among these there was no one totally blind to red; their red vision was merely weak.

After a time I got in touch with two men who could not see red at all. These men had been refused employment on the railway because they could not pass the colour test.

My object was to make a glass screen through which I might see things exactly as they saw

them. The idea was to prevent all red light from entering the eye.

To understand the demonstration, which you may make for yourself, we must have some colour theory to explain matters. One theory, which is quite convenient for our present purpose, says that we have only three colour sensations and that all other colours are combinations of these. The three primary sensations are red, green, and blue, as seen in a spectrum of sunlight, which is produced by passing a beam of light through a glass prism.

In these two men, of whom I am going to write, the red sensation was entirely absent. I had a piece of bright red cloth beside me, and when I threw it over my coat I asked one of the men what he would think if I appeared at a funeral dressed in this cloth. He assured me that that was the way people usually went to funerals; he could not see the red, so that the cloth appeared black. This red cloth was only reflecting red light, and the man had no red sensation to respond to it.

I showed the other man a piece of bright pink cloth, which was reflecting both red and blue light. I knew he could not see the red, and I was not the least surprised when he told me that it was blue. It was a very bright pink,

and I asked him if he would be surprised if I called it sky-blue, whereupon he said he had never seen the sky so blue. He thought that he and I were seeing the same thing, and that the only difference was in our method of describing it. I told him this colour had another name, and I should like very much if he could remember it. After a long pause he suggested "pink." When I told him he was quite right, he said he heard people call it pink sometimes, but he would always call it blue.

I then took a piece of yellow coloured cloth, which I knew was reflecting both red and green light, therefore I was not surprised when the men said it was green, although I saw it as a bright yellow.

Meantime I was making experiments in dyeing films on glass plates, which would allow green and blue light to pass but would keep back all the red. This film which was greenish-blue enabled me to see colours just as the two men described them. The bright red cloth appeared black, the pink appeared blue, and the yellow appeared green.

Instead of making these experiments you may procure a piece of greenish-blue glass from a glass merchant. Tell him you wish the colour which is used in England for railway signalling and which is called "signal-green." It is a

good greenish-blue. The colour used in Scotland is of no use for our purpose as it is a green.

If you happen to know of any firm who make railway signals you could get a piece from them, but any glass merchant will understand what you wish.

If you get a really good greenish-blue glass which will prevent any red reaching the eye you will be able to give a good demonstration of the way in which the colour-blind men usually match colours.

I got the men to match some colours for me, and found I saw them as good matches, so that my glass was all right. I had a pair of spectacles made of the glass, and then I went shopping to try and get larger quantities of coloured wool yarns which I could show to a large audience. I asked for pink and blue wools, and while I was trying to match these the manager of the shop happened to see what I was doing, and he asked if he might enquire why I put pink and blue together, as he had dismissed a salesman who had matched a pink and a blue colour. I told him his assistant had been colour-blind, and that he himself would be temporarily colour-blind if he put on my spectacles.

After he had made a number of "stupid matches," putting pink and blue together,

yellow and green together, red and black, dark rose and dark blue, and so on, I think he felt more sympathy for the assistant he had dismissed because of his stupidity.

If you wish to try matching wools the best way is to take say a pink, and looking through your greenish-blue glass, try the pink beside a number of blue wools till you find one that is a good match.

Another way which is easier as it does not require an exact match is to do as I did in one of my first experiments with the colour-blind man. I showed him a piece of blue silk, and I asked him to suppose that his wife was going out to a party and that she wanted a silk ribbon to match her dress so that she might make a bow of it. I had provided a box of coloured ribbons from which he might select a match. On examining these, he picked out a bright pink ribbon and held it against the blue silk, declaring it was a very good match.

Later I had some bows made of this ribbon and sewed on to the blue cloth. When I showed them to an audience by means of a stage lantern with a greenish-blue screen which cut off all the red, the audience thought the man had been very successful in matching the colours, but when I withdrew the colour-blind screen they saw what a great mistake he had actually

made as the pink ribbons looked ridiculous on the blue silk.

You may be able to find some objects which make a good demonstration. For instance, one of my daughters had a bright red coat with black cloth collar and cuffs and black buttons. I showed this to the audience, and it looked as though it were entirely black. The collar and cuffs looked no different from the coat, and it was a very sombre-looking affair, not at all a suitable coat for a little girl. When I withdrew the colour-blind screen the audience were surprised to find that it was a bright red coat with black collar and cuffs.

If you wish to attempt a demonstration with a lantern, you will find you require to use two thicknesses of the "signal-green" glass in order to prevent any red light leaving the lantern.

If giving a lantern demonstration, it is better to show the audience the objects in the colour-blind light first of all, because so long as some people know that an object is pink they will persist in seeing some of the red, or rather they will imagine that they see it, when you have succeeded in holding back all the red in the lantern. My first experiments were made with an ordinary magic-lantern and two pieces of greenish-blue glass.

How I found out that there was this psychological effect was by a curious incident. I had a lantern operator assisting me in the experiments, and he persisted in seeing some red in a hank of pink yarn when I was satisfied that no red could be seen. The hanks of yarn were hanging over a rod at some little distance from the lantern, the pink yarn being placed next to a blue one so that they would match in the colour-blind light. After a little I walked past the yarns and purposely knocked them so that they fell to the floor. Then in replacing them I transposed them, putting the blue yarn where the pink had been. This was done while the colour-blind light was on. I suggested to the operator that he should stand over where I had been and see if he could still see the red in the pink. Looking at what was really the blue yarn (in the position where the pink had been previously), he said he could still see a tinge of red. I knew the man was honest and thought he saw a tinge of red, even when looking at the blue yarn, which he believed to be the pink yarn. I asked him to bring the pink yarn nearer to the lantern, whereupon he picked up the blue yarn. Holding it close to the colour-blind lantern, he still saw some red. While he was looking at it I withdrew the colour-blind screen from the lantern, and when

he saw he was holding the blue yarn he got quite a shock; he could not understand the transformation until I explained what I had done. I told him also why I had done it.

When I came to give a demonstration before an audience I let them see the things in the colour-blind light first of all, and then they did not know that one of the blues was really a pink, so they failed to see any red in it. Indeed, had I told them that one of the two was pink they could not have told me which was which.

You could procure a piece of bright pink cloth and print a label on it, marking it "Light blue." Then take a piece of dark rose-coloured cloth and label it "navy." Mark a piece of yellow or orange-coloured cloth "green" and label a piece of scarlet cloth "black."

If you show these to an audience in your colour-blind light and tell them that some colour-blind men gave these names to the different cloths your audience will think the colour-blind men were quite right. You then tell them you will show them the cloths as normally sighted people see them, and when you withdraw the colour-blind screen from the lantern they will be surprised to find how easily they have been deceived.

If you have been successful in obtaining a

number of good matches of pink to blue, yellow to green, dark rose to navy, scarlet to black, and so on, it is best to show the matches in the colour-blind light first for the reason already explained.

You may have failed to get perfect matches, in which case you may say that colour-blind people would have picked out these yarns as being of the same colour, one a little darker than the other. Then when the audience seem satisfied with the matches, you let them see how much the yarns differ in each pair.

By a very simple experiment you may prove to your audience that colour is not part and parcel of the object itself, but merely a sensation produced by light.

You may show them what appears to be a jet-black board. I had one made about 2 feet square. I did not have it painted black, but I asked the Tramway Department of the Corporation to paint it the bright red which they use on their stopping posts in Glasgow. I had looked at these posts through my colour-blind spectacles and found that I could not distinguish them from black posts.

After showing the audience your blackboard, and while they are still looking at it in the colour-blind light, you explain to them that the board is not black but it is a bright red.

They can scarcely believe you. Still keeping on the colour-blind light, you explain that you are preventing the red light from leaving the lantern, and as the board is only capable of reflecting red light, there is nothing for it to reflect, so it is colourless or black. When you withdraw the colour-blind screen they are very much surprised to see that the board is such a bright red.

Of course, you must make sure that the paint used is a pure red, and not a mixture of red and blue, as otherwise the board would appear blue in place of black.

If you are going to content yourself with viewing the objects through a piece of greenish-blue glass ("signal-green") and not use a lantern you may find it of more interest to mount the different coloured yarns on small cards such as mending wool is wound upon.

You may then mix up the cards containing light blue, pink, light green, yellow, dark green, orange, rose, dark blue, scarlet, black.

You may use several shades of pink so long as you have found matches for them, but even with ten cards as above you will get much amusement. If you have got a spectacle maker to mount the greenish-blue glass in a cheap pair of spectacle frames, you ask a friend

to put on your spectacles and match the wools while taking care to look directly through the spectacles.

Your friend will place a pink and a blue together, a yellow and a green, and so on, and will think he or she has done very well, until the spectacles are removed, whereupon the absurdity of the matches is exposed.

You may ask them to name the cloths, and you may lay a label on each to show how they have been named. On removing the spectacles your friend will find that a scarlet has been named "black," a rose-coloured cloth is named "navy," an orange cloth "dark green," a yellow "light green," and a pink "pale blue."

One of the colour-blind men with whom I experimented named a rose cloth as "red" each time I showed him it, and yet I was satisfied that the man could not see red at all. Looking through my spectacles I found it appeared a certain shade of blue, so I took some trouble to procure a piece of blue cloth of the same shade as the rose cloth appeared through my spectacles. On the next occasion I showed him this particular blue cloth and he called it red, which proved that he had merely got into the way of calling that blue colouring "red," and when it happened to be rose cloth he was

right, and he was pleased that he could call anything red and be right. You must remember that the colour-blind man, as a rule, does not know that he is seeing anything different from you; he thinks the whole error is in the description of what he sees.

I was able to get one colour-blind man to realise that he really sees things differently from the normal-sighted. We were using the railway test wools, and I put before him a piece of very pale rose and a piece of very dark rose. At the same time I put before him a dark rose and a dark blue. Pointing at the two shades of rose, I asked him if there was any difference, and he said there were miles of difference. I quite agreed with him, and told him that one was a light shade and the other a dark shade of the same colour. Of course he saw them blue and I saw them rose, but that made no difference; we agreed that there were miles of difference. Then, pointing at the dark rose and dark blue, I asked him if there was any difference and he said there was none. I told him that we did not agree. Pointing back to the first pair of two rose shades, I said we were both agreed that there were miles of difference between these two, but to me there were thousands of miles of difference between the second pair, which were entirely different

colours. I told him one was what we call red, which was a colour he could not see, and that it was because he could not see red that he made mistakes in trying to match the wools in which there was any red. The man stared at me as though he wanted to make sure I was not jesting, but he was satisfied that there was more in this matching business than he had thought. When he had been refused admission to the railway work he had thought he was rather badly treated, as he had not realised that he was actually seeing things differently from other people.

If you should be making a lantern demonstration, do not use coloured wools but confine yourself to coloured cottons. The wools are no use with the lantern, for they are what we call fluorescent, and although no red light falls on them they convert some of the other light into red light.

Wools, however, are all right when viewing them through a screen or spectacles, for although they reflect red the red cannot reach the eye because of the glass.

In my lantern experiments I found it necessary to use two thicknesses of greenish-blue glass, but that depends both on the thickness of the glass and upon the power of the lantern light. You will soon find what is necessary to

produce a match, or in other words, what is necessary to keep back all the red so that none is reflected by, say, a pink object, and leaving only the blue to act it appears to match the blue.

CHAPTER VIII

The Dwarf

WHEN I was a boy there was a very amusing performance known as the dwarf. I cannot remember how often I performed this dwarf, but it never failed to provoke laughter. It was well known to a previous generation, and I can remember my father performing it when I was a child.

The dwarf stands upon a table with a curtain as a background (Fig. 92). His legs are very short, but he wears a pair of striped tweed trousers and a coat down to his knees. He has a fat little body and long arms, while his head appears large for his size. He is evidently a foreigner as his English is very imperfect, but he keeps up a breezy patter, introducing many jokes.

His arms keep gesticulating in a most comical manner, and he occasionally adjusts a single eyeglass in his right eye, and then in his left eye. During his speechifying he keeps moving his feet about into different amusing positions,

and will even break into a clog dance. Then he produces a brass whistle from one of his pockets and plays some popular music. He is wearing two small electric lamps as ear-rings;

The Dwarf **Fig. 92**

they are no larger than peas, and one is coloured red while the other is green. As he plays the lamps keep going out and in with the rhythm of the music.

He is wearing a glass tube as a scarfpin, and

while he is speaking this begins to glow, and each time he emphasises a word the glow changes from one end of the tube to the other.

The little man wears an opera hat which he takes off occasionally and closes it. Later on he picks it up, opens it, and puts it on his head.

He keeps up the entertainment quite a long time by simply stringing jokes together. For instance, he tells the audience he does not understand the English words. He was staying at an hotel, and as he intended leaving early in the morning he paid his bill the previous night. In the morning he bade the hotel manager farewell and asked if he owed anything further, whereupon the manager assured him that he was square, and said he hoped he would not be long but would be round soon. The dwarf was glad to get away before he was told that he was flat.

Again he would tell the audience that on one occasion he was hungry but had no money with him. He entered a baker's shop and asked the saleswoman if he might have a bottle of lemonade. She gave him this, but he asked suddenly if she would mind exchanging it for a loaf of bread. She took the lemonade back and gave him a loaf, whereupon he said, " Good morning," and was about to leave the shop when the saleswoman called to him that he

had not paid for the bread. "No!" said the dwarf, "I gave you the lemonade in exchange for the bread." The girl then said that he had not paid for the lemonade. "Not very likely," said the dwarf, "I did not drink it."

Then he would tell how when he was travelling to England the railway people cheated him. They only took half of his ticket when he came across, and he threw away the other half, and they charged him again on his return journey. But on the second journey he said he got equal with them, for he took out a return ticket and he was not going back at all.

I merely give these as examples of the sort of nonsensical speeches which the dwarf made. You may string any series of jokes into a tale. The real amusement was caused by the movements of the little fellow, and the reason why they looked so absurd was that the dwarf was made up of two different persons; the head, body, and feet belonged to one person, and the hands belonged to another person who was hidden behind the curtain.

The principal actor put his head through the stage curtains, which was composed of a pair of heavy curtains pinned together. This actor merely put his head, arms, and shoulders through the curtain, the rest of him was hidden behind the curtain (Fig. 93).

This actor's arms and hands formed the legs and feet of the dwarf. I had a small pair of Wellington boots into which my arms and hands fitted very nicely, but a pair of stockings and shoes will serve the purpose quite well.

I had a pair of small trouser legs made to go one on each arm, and these were tied at the top underneath the coat. I had a coat made specially to fit the dwarf whose body was composed of a rubber hot-water bottle, which was filled with air for the occasion. This rubber bottle was hung round the neck underneath the coat. These were special arrangements of my own.

The usual performance had no special arrangements of this kind, but the advantage in having clothes made to fit the dwarf was considerable. I had the sleeves of the coat left open at the back so that the second actor could slip his arms into them. In this way the coat contains the arms of the one actor (which make the dwarf's arms) and it also contains the arms of the second actor (which form the dwarf's legs). The rubber bag falling between the second actor's arms formed quite a respectable body to fill out the coat.

The actor behind the scenes moves the dwarf's arms in the most ridiculous fashion, which he could not do if he were the speaker,

but as the head of the dwarf belongs to actor No. 2 there is no control of the arms. I think the movement of the arms forms the keynote

The Dwarf's Legs Fig. 93

This actor forms the head, legs, and body of the dwarf.

of the amusement. No. 2 actor controls the feet, which pay no attention to the movements of the arms, as the two are under entirely separate control. Concerted action is required for placing the eyeglass in the eye, and not a little practice is required for this, for No. 1

actor, whose hands have to fix the glass, cannot see even where the head is or in what direction the face is looking.

Practice is also necessary for the handling of the hat, and considerable practice was necessary before we could play the brass whistle.

I was actor No. 2, and I had to do the blowing while actor No. 1 had to do the fingering of the whistle. However, we managed to play quite a number of popular airs, and usually received many encores for this part of the performance. The little electric lamps were lighted by a battery which was behind the curtain, while the switches controlling the lamps were in the boots and were operated by my hands.

The switch for controlling the scarfpin was a more serious problem, as the tube was what is known as a Geissler tube, or vacuum tube, and required a high-tension current which was produced by a battery and induction coil behind the scenes.

I remember on one occasion having some unrehearsed amusement. One of the wires carrying the high-tension current became loosened from the coat to which it had been fixed, and actor No. 1 got in contact with the wire by mistake, causing him to withdraw his

hand quickly, much to the amusement of the audience, who could not understand the antics of the dwarf. Poor actor No. 1 could not see where the wire was, and I was helpless as my hands were in the boots, but, fortunately, after some time the wire got behind the dwarf's tie, and the arms were able to keep clear of it and to continue the performance, but not till actor No. 1 had got more electric shocks than he cared to have.

The movement of the light from one end of the scarfpin tube to the other was worked by means of a reversing key which was in one of the boots, so that it was under my control. By reversing the direction of the electric current the luminous glow moved from one end to the other at will each time the dwarf used any word with emphasis.

If you do not wish to go to so much trouble as we did you may get some amusement without making special clothes.

If you happen to have a door curtained you will be saved some trouble, as you may draw a table up to the door and get behind the curtains. It is not difficult to fix a pair of curtains at a convenient door. It is better if there happen to be two doors to the room, as then the stage may be set before the audience are admitted. When playing in public for

charities we had a special curtain erected between two screens on the stage, and it is possible to adopt this method for a drawing-room entertainment. It is necessary to see that the curtains are fixed securely, as you do not wish to give the show away by exposing what is going on behind the scenes.

If using screens, these should be placed one on either side of the actors, and immediately behind the table which forms the dwarf's stage. The curtains must be arranged so that actor No. 2 can get his head and shoulders through the division, which should then be pinned with safety pins behind his shoulders, leaving the curtain as flat as possible.

Actor No. 1 then puts his arms through the curtain division. If he has no special coat into which he is to put his arms, he merely places them around the shoulders of actor No. 2, whose arms are resting with the hands on the table. After the dwarf is dressed up, the curtain is pinned closely in front of the body of actor No. 2, leaving actor No. 1 enough freedom to move his arms about. If there is no special coat, actor No. 2 may take off his coat and wear it back to the front so that actor No. 1 can get his arms into the sleeves. However, the effect is not nearly so good as with a coat made for the purpose from any odd or

gaily coloured cloth. The sleeves are left open at the back and provided with long flaps so that the shoulders of actor No. 1 cannot be seen.

Explanation of the Dwarf **Fig. 94**

This is how the two actors form the dwarf.

To give an effective performance all must be arranged as to the speech, and although actor No. 1 may carry on with his arms as he likes, it is well that the two actors have some practice in working together. If any one takes the trouble to make the dwarf a proper suit of clothes and to add such things as electric earrings he will find many invitations extended to him. I can remember how we had to bury the dwarf because of the number of performances demanded.

CHAPTER IX

An Imitation of Thought-reading

SOME years ago I gave a demonstration of so-called thought-reading, and you would not find it very difficult to arrange such a demonstration.

Let us first of all look at the performance from the point of view of the audience and then go behind the scenes and see what really took place.

Coming upon the stage, the conjuror shows a pack of ordinary playing cards, from which he asks a lady to draw a card and keep it beside her. He then asks a gentleman to draw another card and to retain it. The remainder of the pack is left on a table within view of the audience and is not touched again. The conjuror explains that he has no idea what cards have been drawn but in a little while he is going to find out through a blindfolded medium.

First of all he wishes to borrow a number of pennies. Those he allows the audience to place in a cloth bag, so that the conjuror does not

touch them. Having collected at least a dozen pennies, he asks one of the audience to draw out any one penny and retain it. The bag with the remainder of the pennies is left on a table in the front of the stage and is not handled again. The conjuror states that he has no idea of the date of the penny which has been selected but he will find it out through his medium.

He then asks a lady to write down any question to which she would like an answer through the medium. A gentleman writes another question, and the two paper slips are placed in an envelope by another gentleman and sealed. The conjuror carries this to the little table, asking the audience to note that he has not opened the envelope, nor does he intend to do so.

The medium is then brought upon the stage. For the medium I used a younger brother who was accustomed to work with me. I asked him if he was aware of what he was to write on the blackboard and he assured me he had no idea. I blindfolded the medium and placed him beside the blackboard; he was seated on a chair with his back to the audience.

A little gentle music was played while I made some mysterious passes of my wand over the head of the medium, at which he apparently

fell into a trance. A piece of chalk was then placed in his rather limp hand and his hand was placed on the blackboard.

I reminded the audience that the medium had assured them he had no idea what he was to write, nor had I any idea, but I wished the lady who had drawn the first card to think very hard of the card selected so that the thoughts might be transferred to the medium and control his hand.

I suggested that the members of the audience on either side of the lady might also see and think of the card.

In a few moments the medium's hand began to write five of diamonds. This was found to be the card selected by the lady. Then the gentleman and two friends beside him thought of the second card selected, and the medium wrote something on the board which I could not see as I had my back turned to the board. I told the audience that it was clear that the thoughts were not transferred through me as I had not the least idea what the medium had written. I asked them if the medium was correct and they said he was, and I saw then that he had written down queen of spades, which agreed with the second card.

I asked that the person who had selected the penny should think of the date, and at

the same time allow it to be passed round the audience so that they could see for themselves that the medium could discover the date.

Gradually the medium's hand began to move, and wrote down 1902, which was found to be the date of the selected penny.

It only remained for the medium to answer the two questions asked. I asked the lady to think of the question she had written down, and taking the envelope in my hand, I said I would not open it until both questions were answered.

The medium wrote down "1314" and then seemed to hesitate. I asked the lady if that was a complete answer and she said it was, so I asked the gentleman to think of his question, whereupon the medium wrote down "In Spain." I then opened the envelope and read one slip which said, "When was the Battle of Bannockburn fought?" and the other slip asked, "Where is Madrid?" I told the audience that I had not known the questions until I read them out.

I then explained that it might seem to them that thoughts had been transferred to the medium in some mysterious fashion, but that the whole affair was trickery which they might try to discover for themselves.

Now you wish to come behind the scenes

and see what really happened. Before going on the stage I take a box of conjuror's cards in which I have ten packs of cards all of the same design on the back, but if you were to examine them you would find that only the first pack is a genuine one. The second pack is made up of fifty-two cards, each of which is an ace of hearts. The third pack is made up entirely of five of diamonds, another is composed of fifty-two queen of spades, and so on. They are all trick packs excepting the first pack.

I take the first pack in my hand. I then select another pack without looking what it is. I place this pack in a broad belt hidden under my waistcoat.

I then select another pack at random and place it also in my belt.

I now pull out any one card from the first pack and hand it face downwards to my assistant, who puts it in his belt without looking at it. I tell him that whatever the card may turn out to be it will be the one selected by the lady. I do the same with a card from the other pack, telling him not to look at it, but that it will be the card selected by the gentleman. Let us follow this out before troubling about the selection of the penny.

When the conjuror goes on the stage he shows

the audience the genuine pack, but turning to pick up his wand, he changes this pack for the first one in his belt, so that when the lady pulls a card from this pack he knows it will agree with the one he has left with his assistant.

In moving across to let a gentleman pull another card, the conjuror changes this pack for the second pack in his belt, allowing the gentleman to retain the card he has drawn. Then on going to lay the cards down on the table, the conjuror takes care to change back to the original the genuine pack, for some curious member of the audience might take a look at those cards at the close of the performance thinking to find they are a dummy pack.

There is really one weakness which it is not necessary to worry about. Were anyone to make a thorough examination of the pack of cards left on the table they would find the five of diamonds and the queen of spades still in the pack, whereas the audience drew these cards. However I have never had anyone make a thorough examination of the pack, and it is not likely to occur to anyone to do so.

Next we come to the handling of the pennies, and you may be surprised to know that I allow the audience to drop in the pennies themselves without my even touching them,

nor do I handle the penny which is selected. How then can my medium tell the date of the penny selected by the audience? Let us get behind the scenes again.

The bag is in reality a double one. It is like a lady's work-bag, with a cloth division or wall in the centre, and it has a tape or ribbon with which you can pull it shut. This tape arrangement also runs through the central wall part, and with a little practice you can open the one side or the other at will. Before going on the stage I take one of several boxes, each of which contains a dozen pennies of a certain date. One box contains only 1898 date, another 1900, another 1902, and so on.

I used to keep a number of groups of pennies in different boxes. In arranging this trick I did not wish to know what date was being used, so I picked a box at random, putting the pennies into one of the pockets of the bag. At the same time I gave my assistant one of the pennies, which he put in his belt without seeing the date of the penny.

On going down to the audience to collect the other pennies I had to pretend my bag was empty; there was no suggestion made one way or the other. I had to be careful to let the audience drop their pennies into the empty side of the bag, and again I had to be careful

to let them draw a penny later from the side in which I had placed the pre-arranged pennies. In this way they were bound to draw a penny which would match the one in my assistant's belt.

It only remained to get the audience to write two questions.

The envelope which I took down to them was empty, but as I had no intention of sealing up the questions in the envelope, I prepared other two similar slips upon which I put any scribble that might represent a question if you merely had a glance at it. These I kept in my belt till such time as I should require them.

On receiving the real question slips from the lady and gentleman, I walked over to someone else to give me an opportunity of changing these slips for the two in my belt. It was the dummy slips which I handed to the other gentleman to seal in the envelope, while the real question slips were safely lodged in my belt.

This changing of things in the belt is not really difficult, as you can make the change either as you walk away from the audience or walk sideways, but I found it particularly easy as I usually dressed up as an aged professor with a loose gown. I had a bald wig and a heavy beard as a disguise.

Now I may bring my assistant on to the stage. This I do without leaving the stage myself. I know that he is armed with the cards and the penny in his belt and I am in possession of the questions.

The medium is able to say truthfully that he has no idea what he is to write upon the board, but when I seat him with his back to the audience and his face to the blackboard, which is on an easel, I stand behind him and make some mysterious passes as though I were hypnotising him. This gives him an opportunity of finding out what the cards in his belt are, also the date of the penny, and the two questions which I had passed to him in the action of blindfolding him. Having given him time to learn his lesson, I can then leave him alone, after placing the chalk in his hand and putting his hand up to the blackboard.

On one occasion my medium surprised me by letting his hand fall from the board to his side, and thinking this was merely some fun on his part, I placed his hand in position again, but once more it came down and the chalk fell on the floor. Then it occurred to me that my medium was not ready. I went behind him and eased the bandage on his eyes, when I was not surprised to see him take another peep at the penny which he had replaced in his belt.

He had not been sure of the date, and wished to make sure before proceeding.

On another occasion I found my medium refuse to let his hand stay on the board, and it was a few moments before I saw that I had placed the chalk in his left hand by mistake.

The thinking on the part of the audience was, of course, bunkum as far as the trick was concerned. This trick served me very well on one occasion to help me out of a difficulty. I was about to give an entirely different imitation of thought-reading at an entertainment on behalf of a well-known charitable institution. On getting to the hall I found my arrangements completely upset by the introduction of some huge palms which had been placed on the platform since I made my arrangements. This was awkward as the thought-reading item was advertised on the programme. Then it occurred to me to replace it by the trick I have just described. I had my cards and coins among my kit, but I had no blackboard and easel. I went to a day school to borrow a board but the school was empty, it being a Saturday and the caretaker was not about, so I seized a board and took it off in a cab, to find on my return later that they had never missed it.

The other form of thought-reading may be

easily repeated by you. Let us see it first of all from the audience's view.

Taking a packet of notepaper from a table, I tell the audience that I wish to give the spirits a sheet of paper on which to write. I place the selected sheet of paper in a little metal frame made to fit it, and I then ask one of the audience to put his signature across the corner of the paper so that he cannot fail to recognise it again, or he may mark the paper in any other way he pleases.

Holding the little frame with the paper so that it is not out of the audience's sight for a moment, I place it in a little wire triangle hanging from the roof, placed in a position so that the audience may see that the frame and paper cannot possibly be tampered with.

I then offer the audience cards and a penny as in the first trick. I then tell the audience that I have no idea of the cards or of the date of the penny selected, but I ask the spirit Ariel to find out from the thoughts of those who selected them, and then to write the results on the paper which is in the little frame.

Ariel is a quick worker, and I may look at the paper at once. Holding this up to the audience, they read, king of diamonds and ten of spades, date 1910, and these are found to be the cards and the penny selected. Yet I

was not aware of these until I saw them on the paper. Then after some further patter I ask the gentleman who signed the paper if he will be good enough to come forward and identify the paper. He examines it and is perfectly satisfied that there has been no trickery in this ; in point of fact it is the same paper. How then is the trick done ?

Let us make another visit behind the scenes. You may guess that the cards were arranged on the same lines as last excepting that I had prepared several boxes each containing two packets of cards lying face downwards, and one of these I selected at random. In the same box was a packet of paper and also a penny lying heads up so that the date was not seen. I placed the coin and the cards in my belt, and put the packet of paper on the table as I entered the stage.

I might have used the bag for a number of pennies, but on this occasion I merely asked for a penny, and on going forward to get it I took it in my hand for a moment and then suggested that the gentleman had better keep the penny himself in case the audience should think I might examine it.

In reality I palmed the borrowed penny and gave the gentleman the penny which I had brought in my belt. He would doubtless have

assured you that his penny was never out of his own hands.

What then about the paper ? It is here that the real trick lies. I had previously prepared several packets of paper each to match the contents of the box in which the packet was placed. I had made a fairly weak solution of cobalt chloride, which when used as an ink is almost colourless, and which is quite invisible if used on a cream-coloured paper.

This invisible ink is easily made, but the strength of the solution can only be determined by experiment. After dissolving a fairly strong solution of this chemical (cobalt chloride), which you may get for a few pence from any dealer in chemicals, try its effect upon the cream-coloured paper. If it shows slightly when dry you must add more water until your writing is quite invisible.

If you then heat the paper gently the writing will appear just as though it had been made with blue-black ink, and it will be fairly permanent. Your only difficulty will be in heating the paper before the audience without letting them know what you are doing.

My first plan was to have a spirit-lamp in an empty tin box lying on its side on a table with the open mouth away from the audience. I then placed the paper in another empty box

and laid it on the top of the box containing the spirit-lamp.

The method I have described is a bolder one. I had a large spirit-lamp hidden behind a stool or table and the wire triangle was hung over this.

As the frame and the paper were hanging in position over the lamp all the time I was letting the audience select the cards and the penny, it had plenty of application of heat. I had to be careful in handing the frame back to the gentleman to identify the paper. If I took it to him at once he would be suspicious when he felt it was heated. I had to carry on some patter after holding it up to the audience and keeping up this patter till the frame cooled down. If you try the frame method you must see that you place the frame in a horizontal position so that the audience cannot see the top of the paper until you hold it up to them, otherwise they might detect the writing before the cards and the penny had been selected. I should advise the spirit-lamp and the empty tin boxes for the first attempt.

You must be willing to take some trouble. The easiest plan would be to prepare only one arrangement of cards and coin, and one sheet of paper with the invisible ink, but in that case you could not tell the audience that you did

not know what the spirits were to write. It is necessary to prepare a number of sets so that you can pick out one at random before going on the stage.

Then again it is not sufficient to prepare only one sheet of paper for each box. It is much more effective to let someone in the audience select a sheet from a packet, and this means that each sheet of paper is prepared in the same way. It does not mean very much labour as there is no difficulty in writing with the invisible ink.

CHAPTER X

Some Conjuring Tricks

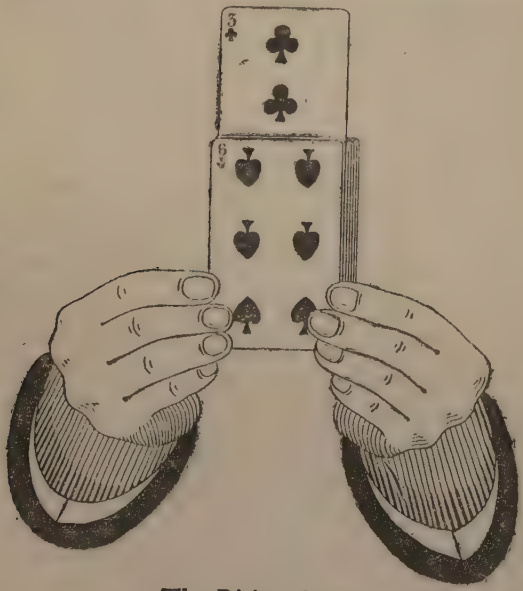
MANY years ago I made an obedient card trick which, to the audience, appeared as follows. A member of the audience was asked to select a card from a pack, and while the conjuror turned his back this card was shown to the audience. The person who had drawn the card kept it in his own hand and put it back in the pack himself, so that the conjuror had no opportunity of handling it or of seeing its face. The selector of the card was then given a broad ribbon to tie around the pack. With this held well up in sight of the audience the conjuror returned to the stage.

After removing the ribbon he held the pack of cards as shown in Fig. 95.

He told the audience he had no idea what card had been selected, but he was going to ask it to rise up out of the pack.

While a little gentle music was played on the piano a card was seen to rise slowly from the pack, as shown in the drawing.

Even after the card had risen with its back to him the conjuror was not aware what the face of the card was, but it was evident from the applause of the audience that the correct card had risen up. I was accustomed to do



The Rising Card Fig. 95

electrical tricks, some of which I have described in *Electrical Amusements and Experiments*. This led people to put the obedient card trick down to some electrical manipulation, but in reality it was much simpler than they supposed, as we shall see if we go behind the scenes.

The forcing of the selected card was done with the conjuror's set of cards as described in the previous chapter. Before going on to the stage I picked one of the packs, which might happen to be all three of clubs, but I put it in my belt without seeing the face, and at the same time I pulled out one of the cards,

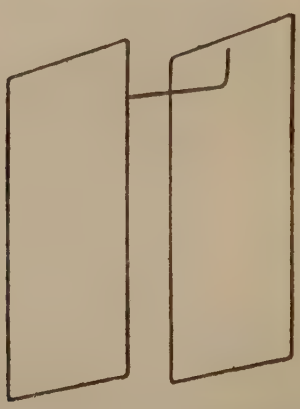


Fig. 96 The Secret Part of the Trick

Here you may see the elastic which joins two of the cards and causes a card between these two to rise.

which was to be the rising card. The rising of the card was obtained in a very simple way.

I took a pack of cards and pasted several together, placing a piece of thin square elastic between two sets of cards, as shown in Fig. 96.

You have to sacrifice one of your packs of cards for the trick, but this has only to be done

once, and the trick can be repeated as often as desired. This preparation is of course all completed long before the time of your first performance. Indeed, the paste must be quite dry before you try the trick.

I think you can guess what the elastic is for. If you push any card down upon the elastic between the two sets of cards the elastic will tend to shoot it out again, but by holding the cards firmly in the hand, as shown in Fig. 95, the pressure may be released very gradually, so that the card rises very deliberately. Indeed the movement looks quite uncanny.

After the conjuror has selected a pack to offer the audience he pushes one card from this pack between the two sets of cards carrying the elastic.

He places these cards about the centre of the pack. It is well to paste several cards on either side of the elastic to ensure that it will hold.

Now you can test the rising card, which you have secured with a ribbon exactly similar to the one you are going to offer the selector of the card. Remove the ribbon and make your test by very gradually releasing the pressure of the fingers. The card will rise up with its back to you, as you do not wish to see its face. Then you can easily push it down again and

tie the pack firmly with the ribbon. This rising card arrangement you place in your belt, as you do not require it until the trick is to be shown on the stage. It goes without saying that you are not going to offer this pack to the audience. You show them a complete pack, but offer them the pack of all one kind. When you turn your back while the drawer of the card shows it to the audience you take this opportunity of changing back to the pack which is correctly assorted. It is this pack which you hand to the drawer of the card, asking him to place the selected card anywhere near the centre of the pack. You then ask him to tie it up with a ribbon, watching that he ties it in a similar manner to the one in your belt.

If necessary, you must show him how to tie it, but this is not usually required.

Immediately on turning your back on the audience you must lose no time in exchanging this pack for the pack prepared with the rising card, and as soon as you have made the exchange, hold up your hand high enough to let the audience see it.

You do not remark upon this or draw attention to it in any way, but as they have no thought of your having another pack similar in appearance they do not suspect you.

The trick has not begun yet as far as they are concerned, but it is practically over as far as the conjuror is concerned, for all he has to do now is to stand in the centre of the stage and release the pressure on the rising card as already described.

It is remarkable how easily people are mystified by this simple trick, but of course you take care that they do not get behind the scenes.

Another trick of a simple nature which I made many years ago was the reappearance of a card which was burnt to ashes before the audience.

Taking a pack of cards, I ask someone to select a card and let the audience see its face while I turn my back. I then hand an empty envelope to the person who drew the card and ask him to place the card in the envelope and then bring it on to the stage.

While this gentleman holds the card I show the audience an empty cardboard box which I ask a member of the audience to tie up in a brown paper parcel and bring on to the stage.

I place the two gentlemen at opposite ends of the stage. I then ask the first gentleman to open the envelope himself and set the card alight, burning it to ashes, which he collects on a tray. I take care not to see the face of the card. He collects the ashes and seals them

up in an envelope and places this in a cardboard box which he ties up in brown paper. He holds this box while the other gentleman holds the empty box securely parcelled up.

I ask the audience to note particularly that I have not touched the boxes, and that I will not leave the centre of the stage, but with a little gentle music I will ask the ashes of the card to reunite and form the card without disturbing the enclosing envelope. Further, I will ask the card and envelope to leave this gentleman's box and go over to the empty box.

With a few magic passes of the wand, keeping to the centre of the stage, I assure the audience that the change has taken place.

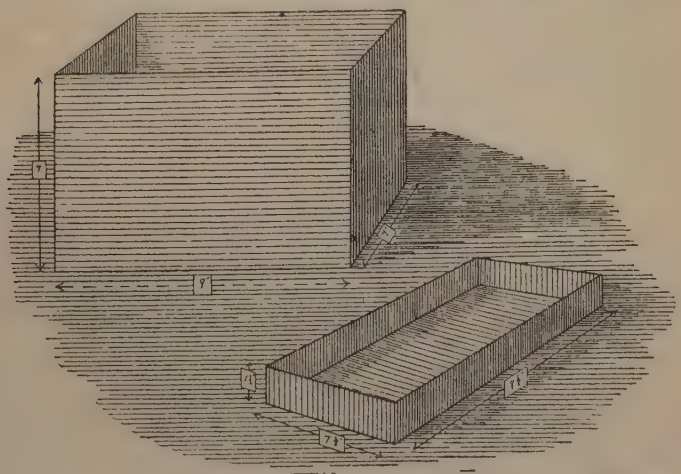
No doubt if I were to open the two boxes they would suspect some sleight-of-hand, but I propose that the gentleman who placed the burnt card in his box should satisfy us that the envelope and card have disappeared. On opening the box he finds it empty.

The other gentleman now opens his box and finds the envelope, and within it the missing card which has no appearance of having been burnt.

If you come behind the scenes you will see how the trick is done.

I have had two pasteboard boxes made with

false bottoms to them. I got a firm of box makers to make these under my direction as I feared I could not make them neat enough Any box maker will be willing to do this for you if you pay the few shillings cost of the time necessary for making them. Indeed, you



Box with a False Bottom **Fig. 97**

will find they are quite interested in this special order.

Tell them you wish the boxes to measure about: length, 9 inches; width, 7 inches; height, 7 inches, as in Fig. 97.

The only thing you are particular about is that the false bottom when raised lies very flat against the side of the box. Also that when

released it is heavy enough to fall down and cover the real bottom of the box.

In handling the box you have to keep your hand firmly grasping the side of the box against which the false bottom rests. It is well to have the boxes made of a dark strawboard of good quality so that it does not stain or mark easily.

Now let us see how these boxes are used in this particular trick.

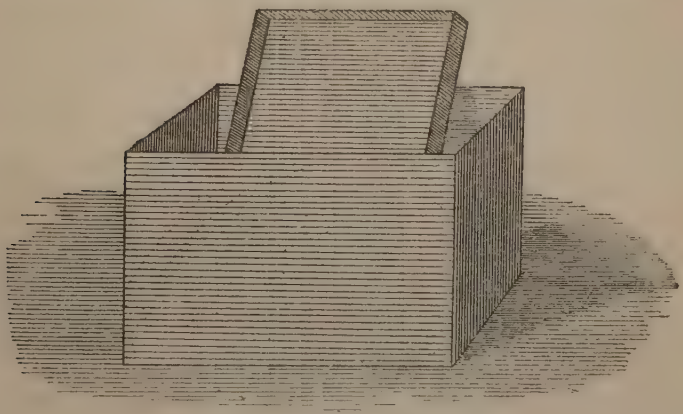
The first box is the one which is supposed to be quite empty, but in reality you have placed an envelope and card on the top of the false bottom, which you have then raised against the side so that you can show it to the audience as an empty box. In the act of putting on the lid you give the box a jolt to ensure the false bottom falling into position, and then you know that when the box is opened at the end of the trick the envelope and card will be found there.

The other box you leave empty, and you have the false bottom raised while you allow the other gentleman to drop in the envelope containing the ashes of the burnt card. Remember when putting on the lid to give the box a jolt so that the false bottom will fall down and cover the envelope and ashes.

The falling of the false bottom in the first box exposes the envelope (with card), while

the same action in the second box hides the envelope (with ashes).

You must not let the audience see you raise the false bottom. This must be done beforehand, and the best way to ensure the false bottom remaining up is to place the lid in the



How to place the Box **Fig. 98**

box when it is left on the table. This is shown in Fig. 98.

Without much practice I have found these tricks with false bottom boxes to be very easily handled.

Another box trick may be made as follows. You show the audience a wooden box which is empty. You borrow a penny, asking the person to note the date so that he may identify it

again. If he likes he may mark the penny in any way he pleases.

You place the penny in the empty box and secure the box with string so that it cannot be opened. You rattle the penny in the box as you carry it to the stage, where you leave the box upon a small table. You invite a boy to come to the stage to assist you in the trick, or you may invite a girl.

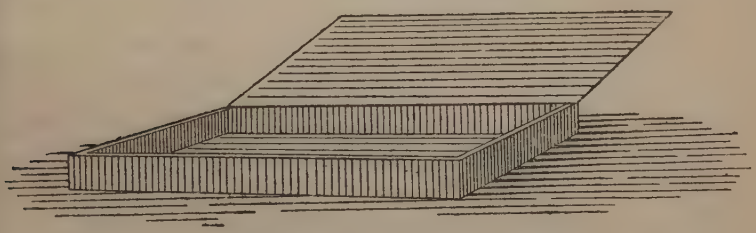
You place the boy or girl at some distance from the table and box, and then standing between them you have a little gentle music while you command the penny to pass from the box to the boy, who is standing with his hands raised over his head.

You ask the boy to open the box, which he finds empty. You then ask him for the penny, and he says he has not got it. You tell him you have not got it, and that pennies are always obedient and go where they are told. You get him to feel his pockets, and he finds it in one of his jacket pockets. You ask him to take it down to the gentleman from whom you borrowed it, and he is able to identify it as his penny.

Perhaps you can guess the trick has something to do with a false bottom, but from the shape of the wooden box, which is quite shallow, it is apparent you cannot raise and lower a

false bottom without it being very visible (Fig. 99).

You may use an empty cigar box, and cut the bottom out of another exactly similar box. This is to form a false bottom, but it is to be a fixture, and you wish it put in off the level so that at one end of the box it touches the real bottom while at the other end there is sufficient space for a penny to rattle from side to side.



A Wooden Box with a False Bottom **Fig. 99**

Before fixing the false bottom in position, you enclose a penny. See that you can rattle it with freedom from side to side, then fix the false bottom with glue or seccotine, placing little pieces of wood underneath to support the end which does not touch the bottom.

What you wish to do is to be able to rattle the penny and then by a quick movement send it to the shallow end, where it will become jammed between the real bottom and the false bottom. When you commence the trick you

have to be careful not to rattle the enclosed penny as the box is supposed to be empty.

When you borrow the penny, take the first opportunity of placing it in your belt, but pretend to carry it in your hand, and pretend to place it in the box, which you immediately rattle to assure the audience that it is in the box.

Before laying the box down on the little table make a quick movement, throwing the penny into a tight place. It is necessary to do this as you are going to allow the boy to open the box later, and he must not hear the penny rattle again, for he finds the box empty.

You will not find it difficult to place the penny in the boy's pocket at the outset when you are arranging the position in which he is to stand. At that time you have not suggested that the boy is to receive the penny, therefore there is no suspicion.

I have even placed the penny beneath the boy's coat collar without any suspicion being raised. The gentleman is able to identify the penny for it is his penny. The only other penny playing a part in the trick is the one to cause the rattle in the box.

You may be interested to see a variation which I made in an old and well-known trick.

Some Conjuring Tricks

I was giving a conjuring entertainment at a Christmas party of boys and girls in a friend's house. I began with a well-known trick, which

Table with Corks **Fig. 100**

Here we see the table ready for the conjuror to start the trick of making the corks pass through the table.

21

consists in putting corks through a table. Probably you all know the trick.

You place the four corks on the table, as shown in Fig. 100.

You then cover up one of the corks with a silk handkerchief, and taking one of the other corks, you place it beneath the table and send it up through the table so that it is lying beside the first cork when the handkerchief is lifted up. Leaving the handkerchief covering these two corks, you take No. 3 cork beneath the table and pass it through so that when the handkerchief is lifted there are three corks beneath it. Then taking No. 4 cork, the same performance is gone through again, and now you have all four corks beneath the handkerchief.

The variation which I made was done intentionally. After putting the third cork through the table I saw the little daughter of the house evidently telling or suggesting to a friend how the trick was done, so I invited her to come and help me with the last cork.

I placed her at some distance from the table, and I asked her if she had a pocket in her dress. She had a pocket, so I suggested that we should put the fourth cork in her pocket. I lifted it from the table and put it in her pocket, asking her to hold the mouth of the pocket shut while she felt with the other hand that the cork was there.

She was quite satisfied that she had the cork securely locked in her pocket. I then suggested

that she should hold her free hand over her head so that the audience might see that she did not assist me in getting the cork to leave her pocket. I took up my position at some distance from her and from the table. With a little gentle music I asked the cork to leave her pocket and go under the handkerchief on the table. On examining her pocket she found that the cork had gone, and she found it under the handkerchief on the table. She was completely mystified and so were the audience, for there was no doubt the cork had been in the girl's pocket, and I had not gone near her after she had closed the mouth of the pocket.

We need scarcely go behind the scenes for the first part of the well-known trick, and yet there may be some reader who has never seen how the trick is done. You have five corks, although you only show the audience four corks. You lay four on the table, and when laying the handkerchief over one of these you slip the fifth cork in beside it.

The best way is to hold the fifth cork between two fingers under the handkerchief and then open the fingers as you lay down the handkerchief. You then pick up the second visible cork and take it below the table. You pretend to pass it up through the table top, but in reality you palm it and keep it hidden

in your palm until you lift the handkerchief to show the pretended arrival of the second cork. Then you lay down the palmed cork with the handkerchief in the manner already described, and you are ready to pass the third cork through the table. The actions are just the same as with the second cork.

For the fourth cork you may repeat these actions, or you may vary it as I did at the children's Christmas party.

Let us get behind the scenes here so that any mystery may disappear, and so that you may repeat the variation of the trick on your own account.

The little girl was so surprised and thought the affair so wonderful that she had to relate it to her father when he came in later. He suggested that I must have been fooling her, and that the cork could not have been in her pocket, but she declared that she had felt the cork in her pocket after she had the pocket closed and after I had left her.

That is what she believed, but what really happened was that the cork was put into her pocket with my hand, whereupon I said the cork is now in your pocket, but it was withdrawn along with my hand. Telling her to take a firm hold of the mouth, I took a fold of her dress in my hand with the cork between

my fingers, and this being beside the pocket, she felt the cork, as she thought, in her pocket. Then, telling her to raise her free hand above her head to avoid any suspicion of assistance on her part, I moved away, taking the cork with me, and placing it in my belt so that it was out of the way.

The fourth cork had, of course, been laid down along with the handkerchief, so that I was free to stand where I was and allow the girl to find it on the table.

Other ways of varying the trick may occur to you, but the one I have described is easily manipulated and gives a new interest to an old trick.

CHAPTER XI

More Tricks

ON one occasion I performed what was in reality a very mysterious trick, as I shall explain later. First let me tell you the trick from the audience's point of view.

At a whist party a lady at the table at which I was seated asked me if I would show them the obedient card trick. Of course, I could not, as I was not prepared with the various trick packs which I have described in the preceding chapter.

I tried to put the lady off by saying I was not inclined to do it at present, but as she insisted on some trick, I took a pack of cards which I handed to her, asking her to select any one card and show it to the others at the table, and then place it herself in the pack. I then asked each of the three players to be sure and remember the card they had seen. Taking the cards in my hand, I said I was willing to shuffle the cards as much as they pleased. I made a

number of shuffles, and they were satisfied that the cards were well mixed.

At this point other members of the party began to gather round the table, so I explained to them that a lady had selected a card from a pack of cards held in her own hands, that she had shown it to other two members of the party, and had then put it back in the pack and mixed the cards before handing them to me. I had done nothing but mix the cards further, and yet I was going to tell her what card she had selected. They said it was impossible.

I laid the cards face downwards on the table, ran my fingers lightly over the backs of the cards, and handing the pack to the lady, I said she had selected the ten of diamonds.

This was correct, and it was, and still remains, a complete mystery to the spectators. I have never attempted to repeat the trick for it is very improbable that I should ever succeed.

It came about in this way. I set out meaning to do a very simple trick, but when shuffling the cards I noticed the lady raise her eyebrows, which apparently meant that she had seen the card. Keeping that card at the bottom of the pack, I attracted their attention for a moment to the next table, giving myself an opportunity

of getting a hurried glimpse at the bottom card. It was the ten of diamonds, and I felt sure this was the selected card.

I continued the shuffling of the cards as though nothing had happened, and it was then that the people began to gather round the table to see a card trick. I felt confident I was going to show them a kind of trick that neither they nor I had seen before, and so I made the most of the occasion by explaining how the card had been selected and placed back in the pack and shuffled before I had an opportunity of touching the cards. It was quite apparently an impossible thing to tell the selected card, and yet I succeeded, but only by the merest accident. Had I not seen the sign of surprise on the lady's face as she caught a glimpse of the selected card again, I could not have told what card she had selected.

Of course the party wished a repeat performance, and of course I refused to repeat it, but I did not tell them that I would never be able to repeat it.

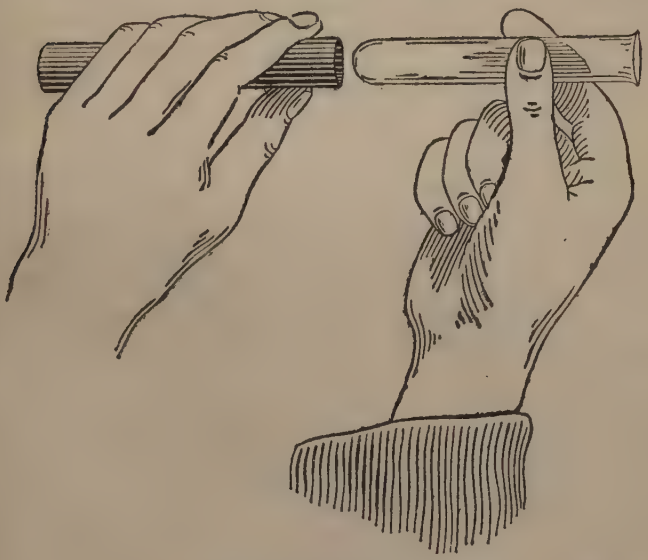
Before explaining some fairly well-known tricks with cards, I might tell you of another entirely different kind of trick which I made up for some little friends.

I made two cardboard tubes each large enough to hold a good-sized glass test tube,

such as may be bought at any dealer in chemicals (Fig. 101).

I placed an empty tube in each of the cardboard tubes, which had bottoms securely fixed in them.

I then asked a boy and a girl to come upon



Glass and Cardboard Tubes **Fig. 101**

the stage, and I asked each of them to hold one of the cardboards containing a glass tube.

I then tied a red ribbon round the girl's cardboard tube, and a blue ribbon round the boy's tube, and poured some red liquid into

the tube with the red ribbon, telling the girl that I had put the ribbon on so that she might be sure to remember the colour of the liquid.

I then poured a blue liquid into the other tube which the boy was holding, telling him that the blue ribbon would remind him of the colour.

Then I had some gentle music, and some

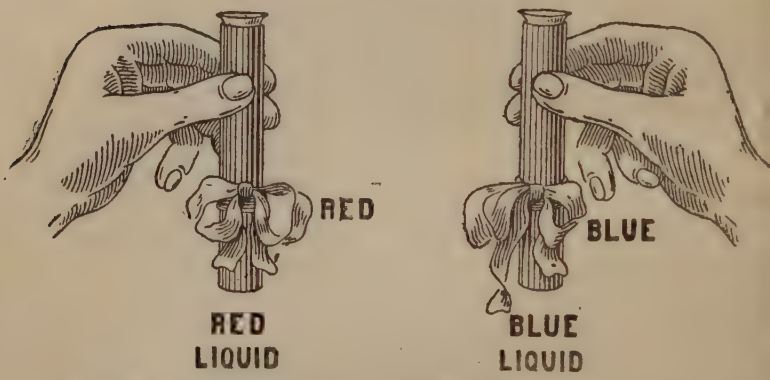


Fig. 102 Tubes with Ribbons

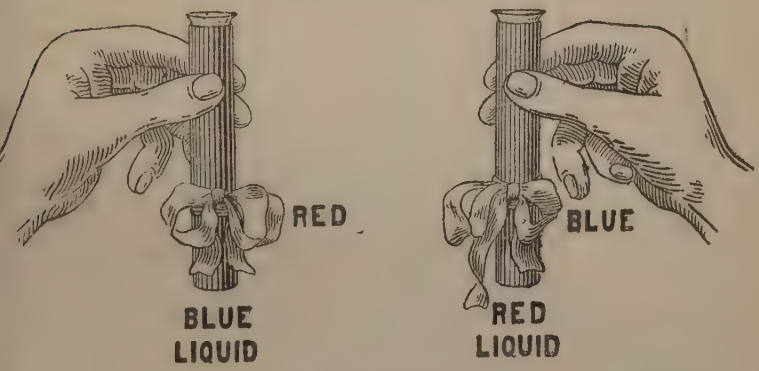
The red ribbon marking the red liquid and the blue ribbon marking the blue liquid.

waving of the magic wand, and when the music ceased I asked the girl if she still remembered the colour of the liquid she had in her tube, and she said it was red. I told her she was surely forgetting, but she looked at the ribbon and said she knew it was red. I told her I felt sure she was wrong, and I asked her to take a

look and see if I was not right when I said it was the blue liquid she had.

She was very much surprised to find that she was holding the blue liquid.

I asked the boy if he had changed the liquids, and he assured me that he had not. I asked him how he came to get the red liquid, but he



Changing Colour **Fig. 103**

The liquids now change from one tube to the other.

said it was the blue one he had. I told him that they could not both have the blue liquid, and when he lifted out the tube he found he had the red liquid.

Some of the audience thought it was done by sleight of hand, but I did not touch the tubes after I poured the liquids in. Here is what happened. The liquids did not change places,

but they changed colour. Red became blue, and blue became red.

Before going upon the stage I painted the inside of one glass tube with a strong acid and the other with a strong alkali, such as ammonia. Most boys will be able to tell that a blue litmus solution will turn red when acid is added. This is a test for acids.

I placed the tube with the acid coating in the boy's cardboard tube, and when I added the blue liquid it gradually turned to red, but he had no opportunity of seeing this as he could not see through the cardboard. I placed the ammonia tube in the girl's cardboard holder and the red liquid turned to blue. Why ?

Because if, after making an acid test, you add a little ammonia to the red liquid it will again turn to blue.

All I required was to buy a little blue litmus at any dealer in chemicals. The litmus is in the form of small blue cubes, which are quite hard. Place these in a glass test tube, and fill about one-half of the tube with water. Then heat the tube in a bunsen burner or, failing that, in a spirit lamp. The water will very soon boil and will become blue. Pour off the liquid, and you now have a litmus solution, which gives you the blue liquid for your trick.

Take another tube of blue litmus solution,

prepared in the same manner, and add to this a few drops of any acid (*vinegar will do*). When you have done this you will find the blue liquid has become a bright red. That is how you obtain the red liquid for your trick. Then you have to prepare the empty tubes which are to be held in the cardboard jackets.

You may coat the inside of one tube with an acid and the other with ammonia, or you may find it easier to place a few drops of acid in the bottom of one of the empty tubes and a few drops of ammonia in the other tube. You may safely pull the empty tubes out of the cardboard covers without these few drops being detected.

Whichever method you adopt, you must be sure to put the tubes back in their cardboard jackets before you pour in the red and blue liquids, or else the audience would see the change take place. As in all good tricks, you have really got matters arranged before the audience know what you are going to do.

You may vary the trick in any manner you desire. Sometimes I fastened a tinsel cord from one tube to the other to make believe that the change took place by means of this connection. Do whatever you think will give most amusement.

It will be greatly to your advantage in all conjuring if you can keep up a patter through-

out the entertainment. I have seen an excellent conjuring entertainment entirely spoilt by the absence of patter.

I remember being very puzzled when I saw the following card trick. Let me describe it first as I saw it.

A friend took a pack of cards and dealt them out into thirteen small packs, face downwards, apparently without much method as he missed some packs and came back to them later, and so on.

Then he picked up the cards, still keeping the faces down, and he now spelt out the cards in this fashion, dealing them at the same time O-N-E—"one," and as he said "one" he turned up the card and it was an ace, T-W-O—"two," and this card was a two, T-H-R-E-E, and the last card was a three. He went right on in this fashion, and after he reached the end of the numerals he spelt out J-A-C-K—"Jack," and sure enough it was a knave. Then Q-U-E-E-N—"queen," and a queen turned up, and finishing with K-I-N-G, the last card was a king. He only turned up the last card of each group, and the spelling of the letters brought out each card as wanted.

I could not understand it, and I thought it rather remarkable that any one had ever noticed that when you spell out one, two, three,

etc., including jack, queen, and king, there is just one letter for each card in the pack. That is, that there are exactly fifty-two letters in all these words.

I got my friend to let me behind the scenes, and I found that he had done some arranging of the cards beforehand of which I had not been suspicious. He showed me how to arrange the cards ; it was a rather complicated process which would be difficult to describe in writing, but I can give you an easy method of arrangement which must of course be done behind the scenes.

Make thirteen packs, and make the first cards laid down be 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, jack, queen, king.

Turn these face downwards in the above rotation. Then add as many cards as required to make up the letters in the word. To the first card you will add other two cards (any cards) as there are three letters in the word one. The second pack will also want two additional cards, as there are three letters in the word two. You must add four cards to the third pack to make up the five letters in three and so on you go till you come to jack, when you make four cards in all, five cards in all for queen, and finish with four for king. This will have used up your whole pack.

Lift the last pile first, which leaves the king at the bottom of the pack, then lift each in turn, and place the packs one above the other in your hand; you will finish by adding the first pack to the top, and you are ready to count out O-N-E—"one," and turning up the third card it is a one.

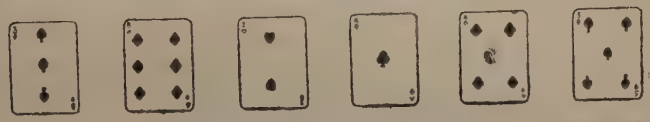
If you wish to arrange the cards before the audience you may do so provided you make the arrangement before you tell what the trick is to be. Otherwise they will be suspicious of the arrangement which must contain one set of thirteen cards from 1 to king.

Here is a fairly simple plan, very much simpler than the original, most of which was really bluff. I think you can do the bluffing in a much simpler manner as follows.

Take the pack of cards in your hands and lay them down in any convenient number of packs, say six packs. All you really wish to do is to build up one pack from 1 to king, and you wish to do this without attracting attention to that row. I find the best way is to take the pack in your hand and commence the first little pack with the first card, continuing along the line thus (Fig. 104):

Build up any of the packs at random, but keep your eye on the one commencing with an ace; put nothing on there excepting a two.

By the way, it may happen that an ace does not come out among the first six cards, in which case you must either leave a blank or start a new row, when one does appear. Two goes on the top of the ace. It may be that "three" is lying on one of the other packs, having been played before the two came out. You are at liberty to move it on to the top of the "two," but make some other move first of all, lifting any one card from one of the other packs to another, then your moving the three is not so



How to place the Cards **Fig. 104**

Commence by laying the cards out in six packs.

noticeable. It does not matter in the end whether any of the other packs have more cards than their neighbours; your sole aim is to build up the one pack with 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, jack, queen, king. I have been surprised how you can get through without raising suspicion, but you have this big advantage that the spectators do not know what the trick is to be or that it is necessary for you to collect these cards together.

Having got this pack complete, you may continue to make any changes among the other

packs as though you were arranging something, but do not on any account let the special cards get out of rotation in the one pack which contains ace to king.

I have even gone the length of mixing what seemed to be the whole pack, but in reality taking care to keep the thirteen special cards on the top undisturbed.

In picking up the cards, you may take them up in any order you please so long as you place the thirteen special cards on the top. You now wish to place the cards down in thirteen little packs like this (Fig. 105) :

You place these face downwards, for these are your trick cards, reading 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, jack, queen, king.

What you wish to do is to arrange them for spelling out later. As the names of all the cards contain at least three letters, you may add two more cards to each pack, laying them face downwards also.

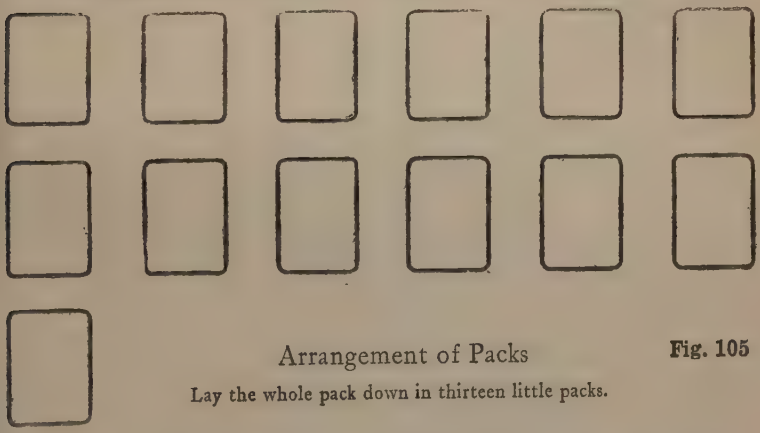
It adds to the mystification if you lay one here, another there, rather than going straight through with the deal. Having placed three cards in all in each pack, you must then think what more you have to add, and so that the spectators will not suspect you of counting, lay only one on a pack at a time.

Commence at the beginning and go straight

through this time, as you wish to remember each of the special cards you are building upon, so that you may know how many cards to have in the pile.

The first card is " one," which is composed of three letters, so you require three cards which are already in position.

The second card is " two." (I am speaking



Arrangement of Packs — Fig. 105

Lay the whole pack down in thirteen little packs.

of the bottom cards, of course.) This has also three letters and is already complete. You therefore add nothing to the first two packs.

But " three " is composed of five letters, so meantime you add one more.

" Four " has four letters, so you add a fourth card making it complete.

" Five " requires another.

" Six " is complete already.

"Seven" wants two more, so you give it one more at present.

"Eight" wants five, so gets another in this round.

"Nine" wants a fourth to complete it.

"Ten" is complete already.

"Jack" wants a fourth card.

"Queen" requires five, but only gets a fourth at present.

"King" gets a fourth, which completes it.

Now for the last round. You must add the fifth card where necessary, i.e. "three," "seven," "eight," and "queen," and in adding one to each of these you have used up all the cards.

You must be careful in picking up these thirteen packs to place the last one at the bottom with the others above it in the order as they lie, so that you finish off by placing the first pack at the top.

You are now ready to count out the cards. As you play the top card (face downwards) you say "O," second card "N" (also face downwards), third card "E," and turning it face upwards you say "one," and the spectators are not a little surprised that it is a one.

So on you go with 2, 3, 4, 5, 6, 7, 8, 9, 10. Then comes "J," "A," "C," "K"—"jack,"

and there comes the jack, and the same upon spelling queen and king.

You will not fail to mystify the audience if you practise the trick well so that you can perform it "without giving the show away." I have found it easy to *apparently* mix the whole pack, but as already said, taking great care (unobserved) not to disturb the top thirteen cards, remember that with the plan I have just suggested you may do whatever you like with the rest of the pack, and add to the mystification as much as you please.

I have never failed to find people puzzled with this arrangement.

Another card trick of a different kind may be of interest to you. It is an old one not much seen now, but I shall give you this just as it used to be performed.

You take a pack of cards and lay twenty cards down in pairs. You may let any member of the audience select what pairs are to be laid down, or better still, let one of the audience handle the cards. While the cards are lying in pairs you ask them to note any number of pairs they care to. Perhaps five members of the audience will each undertake to remember a different pair, while you do not watch in case of any pointing out of cards selected.

You then pick up the cards and lay them

down in this form (four rows of five each) Fig. 106.

You lay the cards face upwards so that the audience may tell you in which rows the cards of their pairs happen to be.

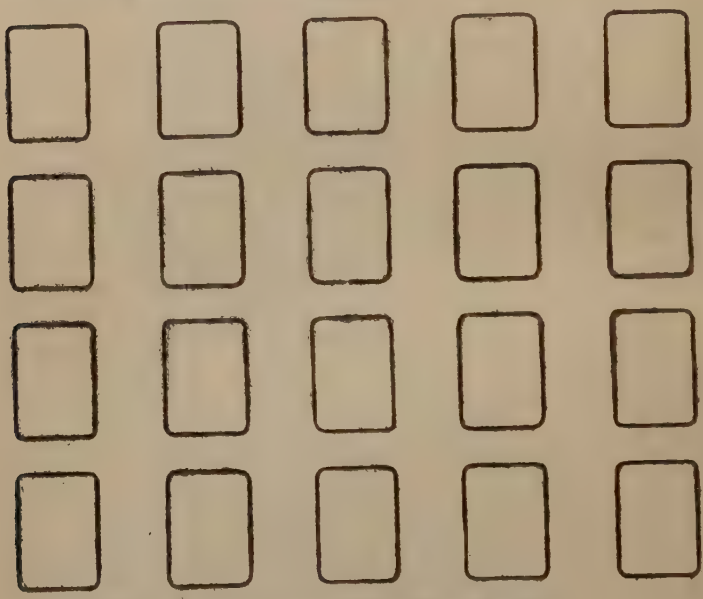


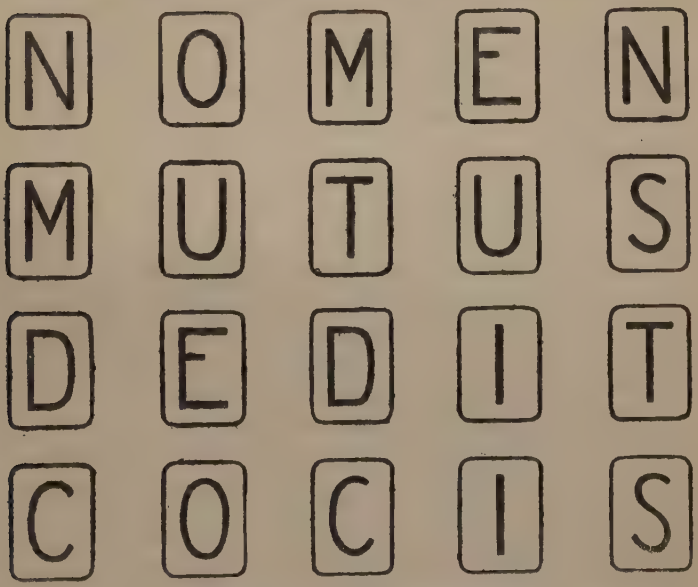
Fig. 106 Four Rows of Five Pairs Each

Lay twenty pairs of cards face downwards on the table.

Someone says his pair is in Row 1 and 3, and you tell them the cards are so-and-so and you are right.

Then someone says the cards of his pair are both in the first row and you are able to tell

the cards. No matter in what row or rows the two cards are, you can always pick them out. Indeed, you could tell the whole ten pairs, although you took no notice of how they were lying on the table when laid down in pairs.



The Words to be Remembered **Fig. 107**

This seems very mysterious, but let us get behind the scenes.

The whole trick depends upon your remembering four Latin words: *nomen*, *mutus*, *dedit*, *cocis*. You have to make a mental picture of these four words placed as above (Fig. 107).

If you examine these words you will see that they are composed of ten pairs of letters.

Two N's in first row.
Two O's in first and last rows.
Two M's in first and second rows.
Two E's in first and third rows.
Two U's in second row.
Two T's in second and third rows.
Two S's in second and last rows.
Two D's in third row.
Two I's in third and last row.
Two C's in last row.

With the above picture (Fig. 107) in your mind, you lay the pairs down where pairs of letters occur.

One pair on the two N's.
Another pair on the two O's.
Another pair on the two M's.
And so on till all the ten pairs are in position.

When someone says his pair are both in the last row, you think of COCIS, and you know that these cards are where the two C's are, viz. first and third in the row, and as the cards are lying face upwards, you name the cards without any trouble.

Then someone says his cards are in the second and third rows. You think of MUTUS
DEDIT
and you know the cards are in the positions

TT, viz. third card of second row and last card in the third row.

It is all a question of visualising Fig. 107, which you will find quite easy.

At first you may require a little time to think the matter out, and this will rather puzzle the spectators, for they know that you paid no attention to the ten pairs of cards which they laid upon the table. What you did take care to do was to keep the pairs in pairs and lay them where Fig. 107 shows two letters the same.

I have found this old trick a great puzzle to friends, and the more you practise it before performing it, the more mysterious it will appear to your audience.

These two card tricks described in this chapter are not suitable for a large audience. They are not tricks for the stage, but for the drawing-room.

Of course, it is not necessary for the other tricks to have a raised stage; you may simply use a part of the drawing-room floor as a stage so long as you have none of the audience behind you. You wish to be able to turn away from them for a moment, or at least sideways to them to make the changes of articles in your belt.

CHAPTER XII

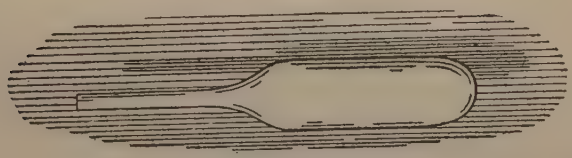
A Scientific Toy

MANY years ago a gentleman told me he had bought a most wonderful thing from a street seller in London, but unfortunately it turned out to be a swindle. So he told me, but when he described it to me I was interested.

He said it consisted of a small glass tube and an ordinary bottle. The street seller had one of these small tubes in what he said was an ordinary glass bottle filled with water. The glass tube floated in a vertical position near the top of the bottle, and the curious thing was that it obeyed the man when he ordered it to sink and rise again. Then he explained that this was done by pressing on the ides of the bottle. He said he merely pressed f rmly with the fingers in which ' e was holding the bottle, whereupon the little tube immediately descended to the bottom and remained there until the man

released the pressure. But when my friend tried the experiment he could not get it to work.

I told him of a scientific toy called Obo which consisted of a glass bottle with a wide neck, over which was fastened a piece of sheet rubber. The bottle was filled with water, and there was a little glass doll floating in it. When you pressed upon the rubber the doll descended to the bottom of the bottle, and it seemed to me this street seller must have had some other



Floating Tube **Fig. 108**

form of the same toy, but I should not have thought that an ordinary glass bottle would do. I found my friend still had the little glass tube so I suggested we should try the experiment again.

My friend went off to arrange the experiment, but came in shaking his head, but I told him it certainly would not work in the way he had arranged, as he had failed to fill the bottle more than three-quarters full. I told him that he must fill the bottle quite full of water, and

when he filled it we got the little tube to fall and rise at will.

Perhaps you will be able to guess how it works if I show you a drawing of the tube. Fig. 108 is what it looked like.

The narrow end is open and the larger end is closed. It floats in the water with the narrow stem down, as shown in Fig. 109.

What happens is this. When you press on the sides of the bottle you force some water to enter the tube through the narrow stem. The additional water makes the tube so heavy that it will no longer float. It descends to the bottom of the bottle. In forcing the water into the tube you have compressed the air in the tube, and when you release the pressure on the bottle this compressed air forces the water out again, and so your tube rises once more to the top.

I got a glass blower at a scientific instrument maker's to blow a few glass bulbs for me and draw out a narrow glass stem. You might succeed in making one of these, though it would not be so neat as the glass blower can do. I think your best plan is to call on any firm who make scientific instruments or deal in chemical apparatus and ask them to make you, say, half a dozen small tubes, as in Fig. 108.

When I had these tubes made I put one in

a large medicine bottle and put it in my pocket when I was going to visit a friend who is very well versed in physics. I reminded him of the Obo toy, of which he possessed one, and I asked him if he thought there would be sufficient

Tube in Bottle (Floating) **Fig. 109**

The little tube will rise and fall obediently in the bottle of water.

elasticity in the glass walls of an ordinary medicine bottle to make the toy act in the same way as when pressing on a rubber mouth-piece. He said he could not think of the bottle being elastic enough for that. I told him that I had thought the same, and he was very much

surprised when I gave him a demonstration with the bottle I had in my pocket.

While speaking to him I said I wondered if we could reverse the action by sinking the doll and pressing on the narrow sides of the bottle,

Fig. 110 Tube in Bottle (Depressed)

By squeezing the sides of the bottle the obedient tube is made to sink.

so that we might release the pressure of the water.

I pressed the cork in gently till the pressure was just sufficient to sink the doll. Then I pressed on the narrow sides of the bottle and up came the tube (Fig. 110).

By pressing the cork more firmly into the

bottle, I had forced some water into the tube, and by pressing the narrow sides or ends to the bottle I enlarged the capacity of the bottle and thus released the pressure of the water, so that the compressed air was able to eject some water from the tube, which then floated to the top of the bottle. It remained there so long as I retained the pressure on the narrow sides. When I released the pressure on the bottle it contracted to its original shape and the water was forced into the tube again, so that it sank.

It is a real marvel that the pressure on the glass bottle is sufficient to do this, for, of course, there is no apparent difference in the shape of the bottle.

Some time later I found a number of the old Obo toys on sale in an optician's. I purchased one of these, and taking the little doll out, put it into an ordinary bottle, as shown in Fig. 111.

The little doll, or imp, has a small hole in the end of its tail, and it is through this hole that the water enters.

The little imp behaves in exactly the same manner as the small tube. Fig. 112 is a front view of the doll.

The imp will act better than the tube, as the doll will turn round and dance. This

motion is got by pressing upon the bottle till the doll stands on the bottom of the bottle. Then gently release, and again apply the pressure at short intervals. This will allow the water to be forced out of the doll and again

Fig. 111 Obedient Doll in Bottle

Using a little doll in the rising and sinking trick.

forced into it. The exit is at the end of the tail, which is twisted round the doll, so that a turning motion is given as the water is forced out.

If you balance the pressure of the water by adjusting the cork so that a very small pressure on the glass sends the doll down, you can then hold the bottle in one hand, as in Fig. 113, and by applying a very gentle pressure of the fingers you can keep the doll at the centre of the bottle as shown. A little additional pressure will send it down very gradually, or a

The Doll Fig. 112

gradual release of the pressure will make it rise slowly to the top.

This addition of water and ejection of it is the principle upon which submarines act. When they wish to submerge they admit water to the tanks, and when they wish to rise to the surface they eject the water.

I had one of these bottles in my study, and one day a little girl brought it to me, saying the doll was drowned, and sure enough the

little doll was lying dead at the bottom of the bottle. Nothing would make it rise.

The reason for this was that someone had doubtless laid the bottle on its side and this had enabled water to enter the doll, which was

Fig. 113 The Doll at the Centre of the Bottle

found nearly full of water. The little girl was quite relieved when I said we could soon revive the doll. We took it from the bottle, lighted a candle, and holding the doll above the flame, we soon saw the water ejected at the tail. What happened was the heat of the candle

expanded the enclosed air, and the expanded air forced the water out.

In putting the doll back into the bottle we found that it wanted to float flat upon the surface, so we had to get some water into the legs of the doll. This we did by holding the doll flat on the surface with the opening of the tail upwards so that some of the air might escape through the water. In a little we had the doll floating in an erect position again.

The same drowning trouble may occur with the little glass tube, but the water is easily expelled by the heat of a candle flame. Take care to hold the tube or the doll an inch or two above the flame, and also to dry the outside of the tube, or otherwise you may crack it.

On putting the tube back in the bottle you may find that it stands erect, but fails to respond to the pressure on the sides of the bottle; it refuses to sink. The reason for this is that the pressure fails to force in sufficient water to sink the tube. You must start with some water in the tube. Indeed, what you aim at having is as much as the tube can carry without sinking.

The trouble is very easily cured. Take the tube out of the bottle, and hold it for a moment with the stem upwards in a basin of water. I have sometimes cured the trouble without

taking the tube out of the bottle. If you press the cork in very firmly you may succeed in forcing the tube to the bottom, then release it quickly and the tube will rise quickly, and in so doing you will see some bells of air escape from the stem, which allows some water to enter.

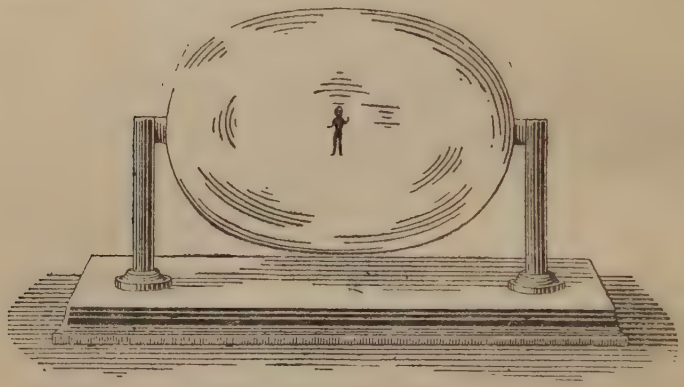


Fig. 114 A Doll in a Glass Globe

This is the showman's obedient doll.

You can only find the correct amount of water by experiment.

When I was a boy I was taken to see a wonderfully obedient doll, at which many people marvelled. It was a larger doll than the imp in the drawing, but was doubtless on the same principle. It rose and sank and turned round at the command of the showman, who never came near it.

The glass globe, a large one, in which the doll was placed was suspended on a brass stand at some distance from the showman, and no one went near it. It was very obedient, but the showman, or more likely an assistant behind the scenes, had some means of altering the pressure of the water. By increasing the pressure of the water, the doll would sink; by releasing the pressure it would rise. By alternate pressure and release it would turn round. It is a very long time since I saw this arrangement, but it was something like Fig. 114.

I have no doubt that there was a water pipe passing up through a leg in the table under the table top and up through the brass stand. There must have been an opening from this pipe into one of the glass supports upon which the globe rested.

The showman took the lease of an empty shop and showed his wonderfully obedient doll, and succeeded in mystifying those who had no knowledge of the old-fashioned Obo toy, upon which principle his doll was worked.

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